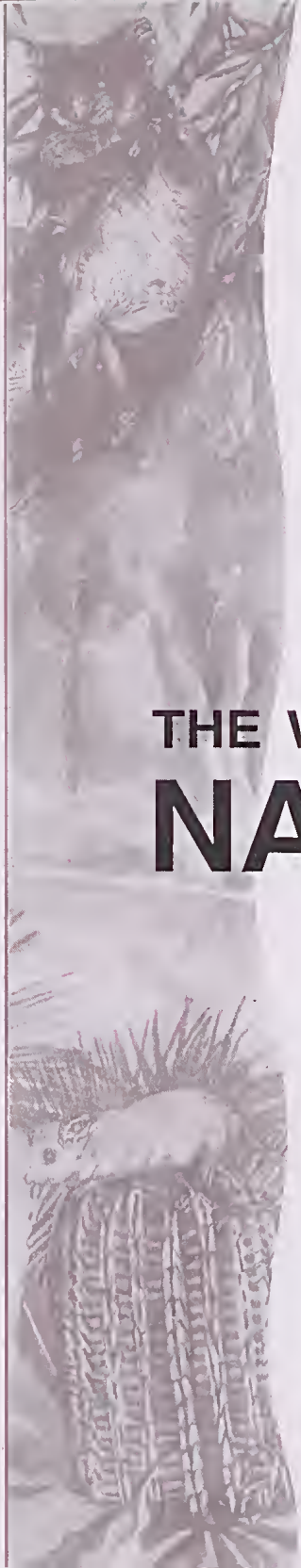

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LAKE GLADSTONE, AN IMPORTANT KIMBERLEY BIRD HABITAT: WITH NOTES ON BIRDS RECORDED DURING THE W.A. NATURALISTS' CLUB EXCURSION ON 12 JULY 2003

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INTRODUCTION

Lake Gladstone is an important bird freshwater habitat in the south central Kimberley. Its European discovery was by Frank Hann on 22 July 1898 who wrote in his diary "There is a fine little lake I have called Lake Gladstone. Camped. I do not know how it get filled as there is not any creek coming into it" (Donaldson and Elliott 1998, p. 83). Lake Gladstone is named after William Ewart Gladstone (29-12-1809 to 19-05-1898) who was a British Liberal politician and four times Prime Minister (1868–1874, 1880–1885, 1886, and 1892–1894). Frank Hann did not mention any birds on the lake but when referring to nearby spider's Lagoon he said "lots of geeses".

Lake Gladstone is located in a reserve currently gazetted for "Public Purposes" and is part of the old Kimberley stock route (Figure 1) which is no longer used for droving cattle.

The first major ornithological survey of the Lake Gladstone area was undertaken during 20–24 July 1968 by members of the 5th Harold Hall Australian Expedition who made collections for the British Museum (Natural History). B.D. MacDonald Booth (in Hall 1974) wrote "This hill lake fringed with tall beds of rush was the home of the Grass and Water Whistling Ducks. Rafts of Green Pygmy Geese, the first we had seen in the Kimberleys, were astonishingly well concealed among the carpet of giant water lilies that hid much of the lake. Apart from the few Royal and Yellow-billed Spoonbills, Straw-necked Ibis and

egrets, there were not the number of aquatic species we had hoped to find. Swathes were cut in the rush for our mist nets though no amount of walking up would induce Reed-warblers to trap themselves." Altogether, Hall (1974) refers to 46 species of birds recorded at Lake Gladstone.

Lake Gladstone was visited for two days from 26–27 October 1977 by R.E. Johnstone of the Western Australian Museum who compiled a list of the 50 bird species that he recorded. This data remains unpublished (Johnstone pers. comm.).

The lake was visited by Buchanan in August 1994 who published a list of 32 species of birds, mainly waterbirds that he recorded (Buchanan 1994). Buchanan was apparently unaware of the previously published records by Hall (1974) and did not mention the visit by Johnstone. Thus the birdlife of Lake Gladstone remained relatively poorly documented. Storr's regional review of Kimberley birds only specifically mentioned Lake Gladstone for eleven species (Storr 1980) and Blakers *et al.* (1984) and Johnstone and Storr (1998) rarely referred to species of birds as occurring there.

Further unpublished data was compiled by Pam Masters (pers. comm.) who visited Lake Gladstone on 13 October 1998 and recorded 29 species of birds.

Because of the paucity of readily available information on such a significant wetland as Lake Gladstone, it was visited by a group of members of the Western Australian Naturalists' Club for about three hours during the morning of 12 July 2003. This was part of the itinerary during the Club's long-range excursion to the nearby Mornington Wildlife Sanctuary which is managed by the Australian Wildlife Conservancy.

When visited in August 1994 by Buchanan the waterbody was described as "about 1 metre deep at the maximum. An irregular shape, some 500 metres by 300 metres in size when visited, with a 50 metre arm to the south east, the lake is obviously very much larger in the wet and over two metres deep." Buchanan (1994) described the lake as having sizeable patches of open water, but the greater part comprised 'rush' most of which were fallen and broken.

However when visited by the Naturalists' Club in July 2003 after a relatively dry wet season, the waterbody was somewhat less extensive than described by Buchanan and probably much shallower with much of the waterbody less than half a metre in depth.

In July 2003 the waterbody was almost surrounded by a partly submerged perennial 'spike rush' sedge *Eleocharis dulcis* about a metre high. Beyond this, particularly in the centre of the lake basin, the *Eleocharis dulcis* was fallen and broken and dry underneath but towards the waterbody the fallen *Eleocharis dulcis* was marshy underneath. On the northern side of the lake were several groups of Freshwater Mangrove *Barringtonia acutangula* which were dry underneath and being used for shade by cattle.

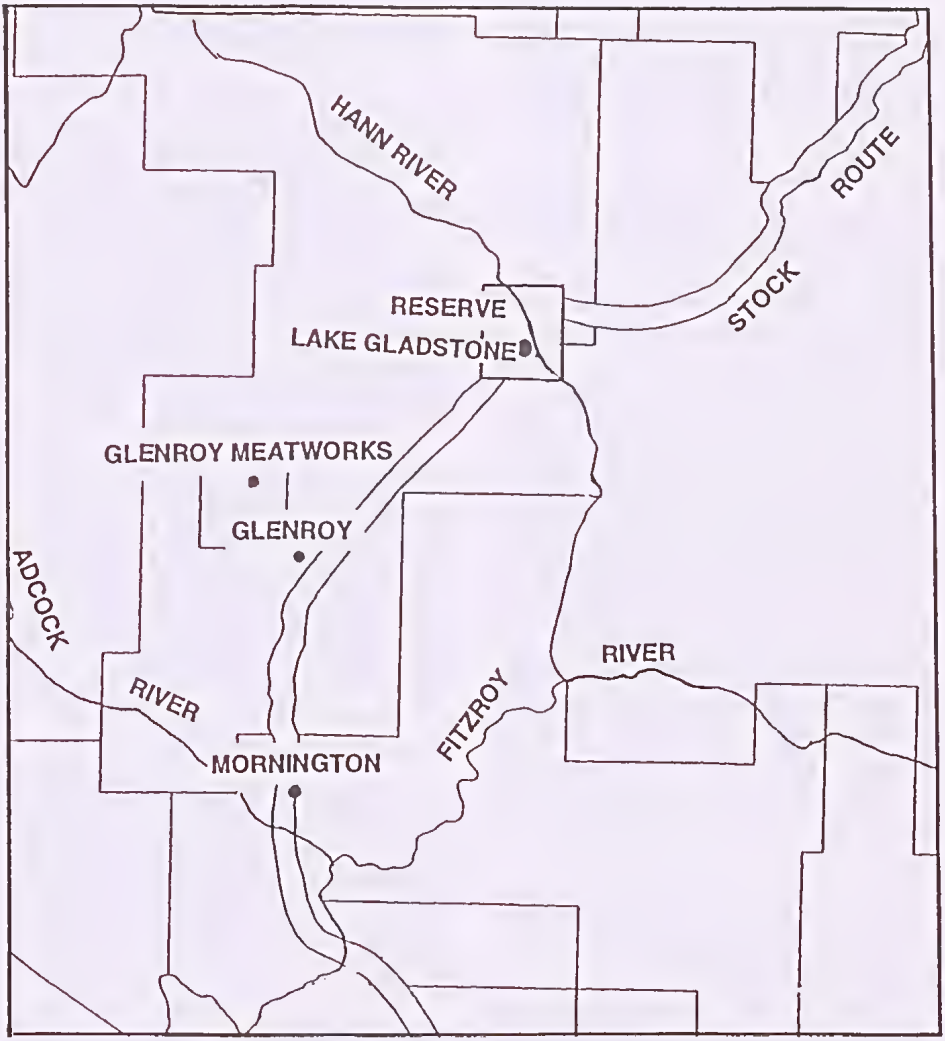

Figure 1. Map showing the location of Lake Gladstone within the public purposes reserve, the Kimberley stock route, the main rives and station boundaries.

During the wet season these Freshwater Mangroves would be standing in water. Around the eastern arms of the lake were tall *Eucalyptus camaldulensis*, River Gum.

Other plants recorded around the lake during the W.A. Naturalists' Club visit on 12 July 2003 by Daphne Choules Edinger (pers. comm.) were *Abutilon* sp., *Acacia* sp. (sterile ?*colei* or *tumida*), *Aristida contortus*, *Bauhinia cunninghamii*, *Carissa lanceolata*, *Cynodon dactylon*, *Eneapogon ?cylindricus*, *Hakea macrocarpa*, *Heliotripium* sp.,

Hibiscus sp., *Lysiana spathulata*, *Melaleuca minutifolia*, *Polycarpaea coryombosa*, *Terminalia canescens* (joolal) and *Triodia schinzii* (curly spinifex).

Cattle were visiting the lake to drink and rest in the shade. At one stage they were wading out in the water of the lake. Accordingly much of the lake edge had very little vegetation having been severely grazed with extensive disturbance to the soil surface.

A total of 38 bird species was recorded at Lake Gladstone during the W.A. Naturalists' Club visit on 12 July 2003. These species are listed in the annotated list below. This list also includes those species previously recorded in July 1968 by members of the 5th Harold Hall Australian Expedition (Hall 1974), in October 1977 by R.E. Johnstone (pers. comm.), in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

ANNOTATED LIST OF SPECIES

Family ANATIDAE

Anseranas semipalmata Magpie Goose. A total of 28 birds scattered around edges of water and in *Eleocharis dulcis* in July 2003. Recorded in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Dendrocygna eytoni Plumed Whistling Duck. Approximately 30 birds on water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), about 100 in October 1977 by Johnstone (pers. comm.), and in August 1994 by Buchanan (1994).

Dendrocygna arcuata Wandering Whistling Duck (Chestnut Whistling Duck). Seven on water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), and 25 in October 1977 by Johnstone (pers. comm.). Storr (1980) refers to this species as occurring at Lake Gladstone. Recorded in October 1998 by Masters (pers. comm.).

Nettapus pulchellus Green Pygmy-goose. Approximately 30 birds on water in July 2003. Previously recorded as parties of 20–30 in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), and 24 in October 1977 by Johnstone (pers. comm.). Storr (1990) refers to this species as occurring at Lake Gladstone.

Anas gracilis Grey Teal. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Anas superciliosa Pacific Black Duck. A total of 53 birds on water in July 2003. Previously recorded as about 50 in October 1977 by Johnstone (pers. comm.).

Malacorhynchus membranaceus Pink-eared Duck. Recorded in August 1994 by Buchanan (1994).

Aythya australis Hardhead. A total of 38 birds on water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in August

1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Family PODICIPEDIDAE

Tachybaptus novaehollandiae Australasian Grebe. Seven on water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in October 1977 (10 birds) by Johnstone (pers. comm.), in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Family ANHINGIDAE

Anhinga melanogaster Darter. One on edge of *Eleocharis dulcis* in July 2003. Previously recorded as 15–20 in October 1977 by Johnstone (pers. comm.) and in October 1998 by Masters (pers. comm.).

Family PHALACROCORACIDAE

Phalacrocorax sulcirostris Little Black Cormorant. One on tree near edge of water in July 2003. Previously recorded as three 25 in October 1977 by Johnstone (pers. comm.) and in August 1994 by Buchanan (1994).

Phalacrocorax melanoleucos Little Pied Cormorant. Three on water in July 2003. Previously recorded as three in October 1977 by Johnstone (pers. comm.), in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Family PELECANIDAE

Pelecanus conspicillatus Australian Pelican. One on water in July 2003. Previously recorded as 15 in October 1977 by Johnstone (pers. comm.), in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Family ARDEIDAE

Ardea alba Great Egret. Three in shallow water in July 2003. Previously recorded as 16 in October 1977 by Johnstone (pers. comm.), in August 1994 by Buchanan (1994), and in October 1998 by Masters (pers. comm.).

Ardea garzetta Little Egret. Previously recorded as four in October 1977 by Johnstone (pers. comm.) and in October 1998 by Masters (pers. comm.).

Ardea ibis Cattle Egret. A total of 21 birds scattered around edges of water and in trampled *Eleocharis dulcis* in July 2003. Recorded in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Ardea intermedia Intermediate Egret. Approximately 30 birds scattered around edges of water and in trampled *Eleocharis dulcis* in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), and in August 1994 by Buchanan (1994).

Ardea novaehollandiae White-faced Heron. Previously recorded as four in October 1977 by Johnstone (pers. comm.).

Ardea pacifica White-necked Heron. A total of 14 birds scattered around edges of water and in trampled *Eleocharis dulcis* in July 2003. Previously recorded as three

in October 1977 by Johnstone (pers. comm.) in August 1994 by Buchanan (1994).

Nycticorax caledonicus Rufous Night Heron. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in River Gums and Freshwater Mangroves in October 1977 by Johnstone (pers. comm.).

Family THRESKIORNITHIDAE

Plegadis falcinellis Glossy Ibis. Previously recorded as four in October 1977 by Johnstone (pers. comm.) and in August 1994 by Buchanan (1994).

Threskiornis molucca Australian White Ibis. Two in trampled *Eleocharis dulcis*. in July 2003. Recorded in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Threskiornis spinicollis Straw-necked Ibis. A total of 29 birds scattered around edges of water and in trampled *Eleocharis dulcis* in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), two in October 1977 by Johnstone (pers comm.), in August 1994 by Buchanan (1994), and in October 1998 by Masters (pers. comm.).

Platalea regia Royal Spoonbill. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), ten in October 1977 by Johnstone (pers. comm.), in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Platalea flavipes Yellow-billed Spoonbill. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. comm.).

Family CICONIIDAE

Ephippiorhynchus asiaticus Black-winged Stork. Recorded in October 1998 by Masters (pers. comm.).

Family ACCIPITRIDAE

Aquila morphnoides Little Eagle. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Milvus migrans Black Kite. One flying above lake in July 2003. Previously recorded in River Gums in October 1977 by Johnstone (pers. comm.).

Haliastur sphenurus Whistling Kite. Two pairs at two nests in tall River Gums near water edge on northeastern side of lake in July 2003. Recorded in August 1994 by Buchanan (1994) and in October 1998 by Masters (pers. com.). Buchanan noted a nest on the eastern side of the lake.

Haliaeetus leucogaster White-bellied Sea Eagle. Recorded in August 1994 by Buchanan (1994).

Circus approximans Swamp Harrier. Recorded in August 1994 by Buchanan (1994).

Family FALCONIDAE

Falco berigora Brown Falcon. One perched on tree several hundred metres from lake edge in July 2003.

Family GRUIDAE

Grus rubicunda Brolga. Two at edge of water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), four in October 1977 by Johnstone (pers. comm.), and in October 1998 by Masters (pers. comm.).

Family RALLIDAE

Fulica atra Eurasian Coot. A total of 38 birds on water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in October 1977 by Johnstone (pers. comm.), and in August 1994 by Buchanan (1994).

Porphyrio porphyrio Purple Swamphen. Six in *Eleocharis dulcis* in July 2003. Recorded in August 1994 by Buchanan (1994).

Family OTIDIDAE

Otis australis Australian Bustard. Previously recorded as four on dry mud flats in October 1977 by Johnstone (pers. comm.).

Family SCOLOPACIDAE

Tringa glareola Wood Sandpiper. Previously recorded as one on lake edge in October 1977 by Johnstone (pers. comm.) and in August 1994 by Buchanan (1994).

Tringa hypoleucos Common Sandpiper. Previously recorded as six in October 1977 by Johnstone (pers. comm.) and in August 1994 by Buchanan (1994).

Calidris acuminata Sharp-tailed Sandpiper. Previously recorded as about 30 in October 1977 by Johnstone (pers. comm.).

Family JACANIDAE

Metopidius gallinaceus Comb-crested Jacana. Two in shallow water on edge of *Eleocharis dulcis* in July 2003. Recorded in October 1998 by Masters (pers. comm.).

Family RECURVIROSTRIDAE

Himantopus himantopus Black-winged Stilt. Previously recorded as six in October 1977 by Johnstone (pers. comm.) and in August 1994 by Buchanan (1994).

Family CHARADRIIDAE

Vanellus miles Masked Lapwing. Two among trampled *Eleocharis dulcis* in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), about 20 in October 1977 by Johnstone (pers. comm.), in August 1994 by Buchanan (1994), and in October 1998 by Masters (pers. comm.).

Charadrius melanops Black-fronted Dotterel. Previously recorded as "very common probably about 100 at the lake" in October 1977 by Johnstone (pers. comm.), in August 1994 by Buchanan (1994), and in October 1998 by Masters (pers. comm.).

Family GLAREOLIDAE

Stiltia isabella Australian Pratincole. Two among trampled *Eleocharis dulcis* in July 2003. Previously recorded as two on dry mud flat in October 1977 by Johnstone (pers. comm.) and in August 1994 by Buchanan (1994).

Family LARIDAE

Sterna hybrida Whiskered Tern. Previously recorded as ten in October 1977 by Johnstone (pers. comm.).

Family COLUMBIDAE

Geophaps plumifera Spinifex Pigeon. Recorded in August 1994 by Buchanan (1994).

Geopelia humeralis Bar-shouldered Dove. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Geopelia striata Peaceful Dove. One at edge of lake in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family PSITTACIDAE

Calyptorhynchus banksii Red-tailed Black Cockatoo. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), and in October 1998 by Masters (pers. comm.).

Cacatua roseicapilla Galah. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Cacatua sanguinea Little Corella. Approximately 30 in tall River Gums near water in July 2003. Previously recorded as common in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in October 1998 by Masters (pers. comm.).

Nymphicus hollandicus Cockatiel. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Aprosmictus erythropterus Red-winged Parrot. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family CUCULIDAE

Cacomantis variolosus Brush Cuckoo. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Chrysococcyx basalis Horsfield's Bronze Cuckoo. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family STRIGIDAE

Ninox connivens Barking Owl. Previously recorded as three calling at night in October 1977 by Johnstone (pers. comm.).

Family ALCEDINIDAE

Dacelo leachii Blue-winged Kookaburra. Previously recorded as calling at night in October 1977 by Johnstone (pers. comm.).

Todiramphus sanctus Sacred Kingfisher. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in River Gums and Freshwater Mangroves in October 1977 by Johnstone (pers. comm.).

Family MEROPIDAE

Merops ornatus Rainbow Bee-eater. Four sallying out to catch insects over water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in October 1998 by Masters (pers. comm.).

Family ACANTHIZIDAE

Gerygone olivacea White-throated Gerygone. Previously recorded in October 1977 by Johnstone (pers. comm.).

Smicrornis brevirostris Weebill. Previously recorded in October 1977 by Johnstone (pers. comm.).

Family MELIPHAGIDAE

Lichmera indistincta Brown Honeyeater. One in River Gums near water in July 2003.

Lichenostomus flavescens Yellow-tinted Honeyeater. Two in tall River Gums near water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in October 1977 by Johnstone (pers. comm.), and in October 1998 by Masters (pers. comm.).

Lichenostomus plumulus Grey-fronted Honeyeater. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in River Gums and Freshwater Mangroves in October 1977 by Johnstone (pers. comm.).

Lichenostomus unicolor White-gaped Honeyeater. Previously recorded as four in River Gums and Freshwater Mangroves in October 1977 by Johnstone (pers. comm.).

Ramsayornis fasciatus Bar-breasted Honeyeater. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974). Storr (1980) listed this species presence at Lake Gladstone, presumably referring to the record by Hall (1974).

Conopophila rufogularis Rufous-throated Honeyeater. Previously recorded as feeding over water from perch on top of cladium in October 1977 by Johnstone (pers. comm.).

Melithreptus albogularis White-throated Honeyeater. Previously recorded in October 1977 by Johnstone (pers. comm.).

Melithreptus gularis Black-chinned Honeyeater. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in River Gums and Freshwater Mangroves in October 1977 by Johnstone (pers. comm.).

Philemon citreogularis Little Friarbird. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family PACHYCEPHALIDAE

Pachycephala rufiventris Rufous Whistler. One in Freshwater Mangroves on north side of lake in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974), in October 1998 by Masters (pers. comm.).

Family DICRURIDAE

Myiagra inquieta Restless Flycatcher. One in River Gums on edge of water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Rhipidura leucophrys Willie Wagtail. Three feeding around edge of water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian

Expedition (Hall 1974) and in October 1977 by Johnstone (pers. comm.).

Rhipidura rufiventris Northern Fantail. One in Freshwater Mangroves on north side of lake in July 2003.

Grallina cyanoleuca Magpie-lark. Seven scattered around edges of water in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in River Gums and Freshwater Mangroves in October 1977 by Johnstone (pers. comm.).

Family CAMPEPHAGIDAE

Lalage tricolor White-winged Triller. One in trees near edge of lake in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Coracina papuensis White-breasted Cuckoo-shrike. One in tall River Gums near water in July 2003. Previously recorded in October 1977 by Johnstone (pers. comm.).

Coracina novaehollandiae Black-faced cuckoo-shrike. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in October 1977 by Johnstone (pers. comm.).

Family ORIOLIDAE

Oriolus sagittatus Olive-backed Oriole. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family ARTAMIDAE

Artamus cinereus Black-faced Woodswallow. Previously recorded in October 1977 by Johnstone (pers. comm.).

Artamus leucorynchus White-breasted Woodswallow. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Artamus minor Little Woodswallow. Several flying above lake in July 2003. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in October 1977 by Johnstone (pers. comm.).

Family CRACTICIDAE

Cracticus nigrogularis Pied Butcherbird. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family PTILONRHYNCHIDAE

Ptilonorhynchus nuchalis Great Bowerbird. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in October 1977 by Johnstone (pers. comm.).

Family HIRUNDINIDAE

Hirundo ariel Fairy Martin. Two feeding above water in July 2003.

Hirundo nigricans Tree Martin. Previously recorded as ten hawking over water in October 1977 by Johnstone (pers. comm.) and in October 1998 by Masters (pers. comm.).

Family CORVIDAE

Corvus orru Torresian Crow. Recorded in October 1998 by

Masters (pers. comm.).

Family SYLVIIDAE

Acrocephalus australis Australian Reed Warbler. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974) and in August 1994 by Buchanan (1994).

Family ALAUDIDAE

Mirafra javanica Singing Bushlark. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family PASSERIDAE

Taeniopygia guttata Zebra Finch. Previously recorded as 30 in October 1977 by Johnstone (pers. comm.)

Poephila acuticauda Long-tailed Finch. Approximately 28 came to drink at edge of water in July 2003. Previously recorded as ten in October 1977 by Johnstone (pers. comm.).

Poephila bichenovii Double-bar Finch. Recorded in October 1998 by Masters (pers. comm.).

Erythrura gouldiae Gouldian Finch. Previously recorded in August 1994 by Buchanan (1994) who recorded five juveniles.

Heteromunia pectoralis Pictorella Mannikin. Previously recordedin July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

Family MOTACILLIDAE

Anthus australis Australian Pipit. Previously recorded in July 1968 by the 5th Harold Hall Australian Expedition (Hall 1974).

DISCUSSION

Combining the list of 46 species listed by Hall (1974), the 50 species recorded in October 1977 by Johnstone (pers. comm.), the 32 bird species recorded by Buchanan (1994), the eleven species referred to by Storr (1980) and Johnstone and Storr (1998), the 29 species recorded by Masters in October 1998 (pers. com.), and the 38 species recorded on the W.A. Naturalists' Club excursion in July 2003 a total of 97 species have now been recorded at Lake Gladstone. Lake Gladstone is therefore an important habitat for waterbirds and landbirds that utilize areas adjacent to water in that part of the south central Kimberley where other freshwater lakes do not occur.

As Lake Gladstone is being significantly degraded by cattle which use it for watering and shelter, it is recommended that it be managed for conservation. To achieve this aim the Western Australian Naturalists' Club recommends that the lake should be fenced with a cattle and donkey proof fence to exclude feral stock.

ACKNOWLEDGEMENTS

Grateful thanks are extended to John Luyer and other members of the W.A. Naturalists' Club for organizing this long-range excursion. Daphne Edinger kindly provided a list of plants recorded at Lake Gladstone in July 2003

and John Luyer and Trish Gardner made comments on the manuscript. John Luyer and Ron Johnstone also provided information on references. This paper has benefited considerably from the list of birds recorded in October 1977 by Ron Johnstone and in October 1998 by Pam Masters, both of whom kindly allowed me to use their unpublished information.

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SUCCESSFUL TRANSLOCATION OF A MATURE FEMALE RIDGE-BACK TRAPDOOR SPIDER (IDIOPIDAE; *IDIOSOMA SIGILLATUM* (CAMBRIDGE))

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Female trapdoor spiders may be quite long-lived, and, once established, remain sedentary for the remainder of their life. Spiders may thus persist in undisturbed locations for long periods. They are often found within very small areas of native bushland within farmland, and even in suburbia. The dislodging in early Spring 2001 of a large female Ridge-back Trapdoor Spider (*Idiosoma sigillatum)* during renovation of a garden bed of 'Day Lilies' (*Hemerocallis* sp.) at the side of a long established Nedlands- house (built *c.* 1938) provided another example of this persistence. The intact live specimen retained also provided opportunity for attempting relocation.

I. sigillatum is widely distributed in sandy areas of the Swan Coastal Plain, as well as being found on Rottnest Island (Main 1990). Choice of a translocation site was based on the need for a sandy location readily accessible for further observation but also unlikely to suffer physical disturbance in the future. The site I chose for the experiment was within mixed Banksia/she-oak woodland on the CALM Woodvale Reserve (No. 30809).

Because mature spiders appear unable to initiate construction of new burrows it was necessary for me to provide a new hole in which the spider could seek refuge to prevent it wandering aimlessly in the bush and perishing on release. With *I. sigillatum* being one of the 'twig-liner' species, I also looked for a spot where linear litter could be readily available to the spider if it were to be capable of making a new home. Finally, I selected a site beside the base of a she-oak (*Allocasuarina fraseriana*) partially sheltered by a fallen log.

Making a rough estimation of the spider abdomen diameter, I chose a strong straight stick of slightly greater width, and, using firm hand pressure, pushed a vertical hole of c.18–20cm depth into the sandy soil. On my gently inclining the container in which I had the spider toward the lip of the newly constructed hole, the spider slowly crawled out, and somewhat to my surprise went straight down the hole without hesitation. No other assistance was

provided. The release was made late afternoon *c.* 2 days after the spider was dislodged from its original home, and was completed at *c.* 5:30pm on or about 8 October 2001.

I was unable to check the site again until the morning of the second day following (*c.* 40 hours later). When I did, I discovered that the spider had constructed a well-formed burrow lid complete with small bits of dry bark, etc. on the top, and had attached some other bits of litter around the lip of the hole opposite the hinge. The top inside section of the hole also appeared to be webbed in. I made no attempt to look further down into the burrow to see what the spider had done further below ground for fear of unacceptable disturbance.

Whilst I had had no particular hope that the spider might stay put, if not be predated on during exposure while at work after dark on the first night following release, the new accommodation provided had obviously proven acceptable and was being refurbished to suit the spiders immediate need. The next question would be whether the new home would suit the spider in the longer term. Possible desiccation over summer posed a further risk to survival.

Irregular site inspections suggested the spider was still present up to early December 2001. The burrow still appeared

Figure 1. The new burrow and surrounds at June 2002 of an adult female Ridge-back Trapdoor Spider about nine months after translocation from a Nedlands suburban garden to the Woodvale Nature Reserve. Scale = 20cent coin at rear hinge of burrow lid. Photo: R.I.T. Prince.

intact when next able to be inspected late January 2002, but whether the spider might still be alive was uncertain. Survival over summer was confirmed in May 2002 when it was ascertained that new bits of litter had been attached on the lid and around the lip of the burrow, which had been remodelled. Some additional she-oak needles had also been added to the twig 'moustache' characteristic of this species.

Photographs of the site were taken in early June 2002 (Figure 1). Some Perennial Veldt grass (*Ehrharta calycina*) had resprouted adjacent to the burrow, and some nest building by small ants was noted nearby. The spider was seen to have added further material to the twig 'moustache' by early July 2002.

The spider itself had not been seen through December 2002, and the early summer drought had dried the litter layer on site. However, the burrow surrounds remained in good condition. Further 'housekeeping' tests initiated from January 2003 on by placing a small twig transversely across the lip of the burrow lid onto the twig 'moustache' during late afternoon have invariably been followed by removal of this impediment, usually overnight. The spider has remained alive in its new home for c. 23 months to date (5 September 2003). The main risk to future survival now appears to be fire.

The successful translocation of this spider suggests that translocation of adult trapdoor spiders from badly disturbed habitats could be further tested as a conservation option, especially for some of the rarer and geographically restricted species.

ACKNOWLEDGEMENTS

I thank Clare Woods for saving the spider, and Barbara Main, Paul van Heurck, and Mike Gray for their comments and interest in this matter.

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THE BIOGRAPHY BEHIND THE BIRDS (NO 20 IN THE SERIES). RUFOUS SONGLARK (*CINCLORAMPHUS MATHEWSI*) IREDALE, 1911.

By TESS KLOOT
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Tracing and reproducing the original source of the naming of a bird is, to my mind, a satisfactory completion of its life history.

Of the ninety or so scientific names that commemorate individuals who have made a significant contribution to Australian ornithology that of Gregory Macalister Mathews (1876–1949) is one of the better known. He was a somewhat controversial figure in his day, mainly in the field of taxonomy. He indulged a propensity to create subspecies. As a consequence many attempts were made to perpetuate his name in subspecies (RAOU Checklist – 1926). Today only *Cincloramphus mathewsi* survives (Christidis and Boles 1994). Despite all the controversy surrounding his work he did, however, make a very substantial contribution to our ornithological knowledge.

NAMING THE BIRD

Rufous Songlark *Cincloramphus mathews* Iredale, 1911. (*cinclos* – bird Gk. *ramphos* – bill Gk.) (Jobling 1991).

"Mr G.M. Mathews described the following new birds from Australia:–

On behalf of MR TOM IREDALE, MR OGILVIE-GRANT forwarded the description of a new subspecies of *Cincloramphus* from West Australia. Mr. Iredale described it as follows:–

CINCLORAMPHUS RUFESCENS MATHEWSI, subsp. n.

Adult male. Differs from C.r. *rufescens*, Vig. & Horsf., in being much darker above, and in having a shorter bill and longer wing....

The type *of C.r. mathewsi* is from Yalgo [sic], West Australia, and is No. 5198 in the collection of Mr G.M. Mathews".

Bulletin of the British Ornithologists Club No. CLXXI, Vol xxvii, 1911. pp 97–98.

GREGORY MACALISTER MATHEWS (1876–1949)

Gregory Macalister Mathews was born on 10 September 1876 at Merrygoen, New South Wales. He was educated at Singleton Grammar School and The King's School, Parramatta. During his boyhood he was an enthusiastic collector of bird's eggs – perhaps an early sign of the course his life

Figure 1. Gregory M. Mathews, C.B.E. 1939. Reproduced from: Birds and Books by G.M. Mathews, Verity Hewitt, Canberra, 1942.

was going to take. In Queensland he worked in mining, and on a cattle-station for six years, observed birds on droving trips, and indulging his love of horses. He returned to New South Wales to become an orchardist.

On 6 May 1902 he married Marion Cecil Wynne, a widow with two children. She was the daughter of Henry Charles White and first cousin to Henry Luke White – another well-known name in the ornithological world of the day (White 1981).

They sailed for England soon after where Mathews was to live for the rest of his life. They first settled at "The Larches", Wadhurst, near Tunbridge Wells (Mathews 1942). Hunting, races and horse shows formed a major part of his life until a visit to the British Museum of Natural History. Here he conceived the idea of producing an exhaustive work on Australian birds. Encouraged by R. Bowdler Sharpe, keeper of the bird collection, Mathews commenced this enormous undertaking. To be near the British Museum of Natural History he soon moved to Langly Mount, Watford. Working to the point of fanaticism he spent sixteen hour days in research, writing, skin- and book-collecting. Helped by hired collectors he ultimately amassed some 30,000 specimens. His library of 5000 books, which understandably, took many years to accumulate, covered every aspect of ornithology. The first volume of *Birds of Australia* appeared in 1910. From 1911 he was assisted by Tom Iredale who became his amanuensis. Between them they produced a staggering amount of work until Iredale left for Australia in 1923. The final volume – Volume 12 of *Birds of Australia* – appeared in 1927.

"In 1914 Mathews undertook a world tour, meeting ornithologists and extensively examining skins. Returning just before World War 1, he settled in Hampshire at Foulis Court, Fisher's Pond" (Kloot 1986).

Mathews also published lists of Australian, New Zealand, Lord Howe and Norfolk Island birds, plus numerous articles, some of them supporting his taxonomic

views. To further advance his ideas he established in 1912, the *Austral Avian Record*, editing it throughout its 15 years of existence.

Inevitably, H.L. White and Mathews were to be in touch for about two decades and White did much to help Mathews by lending him skins (White 1981). Due to the worldwide depression in the late 1920's Mathews fell on hard times and was forced to sell his home and collections. White, who again did much to assist him, hoped the skin collection would return to Australia, but the price asked for it by Mathews was too high, and it was bought by Lord Rothschild. In 1932 Mathews learned that Rothschild had sold the entire collection to the American Museum of Natural History where it remains today. The skin of *Cincloramphus mathewsi*, collected in Yalgoo, Western Australia, is also there.

The sale of skins to America determined Mathews to donate his very valuable ornithological library to "..... his native country of Australia and in 1939 he offered the collection to the National Library of Australia, and accompanied the books from England the following year." (White 1981). During 1940–1945 he supervised its housing in the National Library, Canberra. In 1942 he published his autobiography, *Birds and Books: The Story of the Mathews Ornithological Library.*

Mathews was a fellow of the Royal Society of Edinburgh, and was associated with many worldwide scientific bodies.

He returned to England in 1945, and died of cancer on 27 March 1949.

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(Editors Note: For Club members who have access to the Club library there is further biographical information on G. M. Mathews in *The Emu*, vol. 49: 145–148 and *The Ibis*, vol. 91: 521–524 and a photograph of him with our Club founder Dr D.L. Serventy and the Museum Director Mr L. Glauert in the *Western Australian Naturalist*, vol. 17: 218).

MASS DEATHS OF SEA TURTLES ON THE MONTEBELLO ISLANDS, OCTOBER 1953, FOLLOWING OPERATION HURRICANE

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The following note is derived from a conversation I had with Mr Max Kimber in December 2002, and with Mr Colin Bromfield in January 2003. Although nearly 50 years after the events described, both men's recollections were clear and vivid. Despite the absence of scientific corroboration, it seems that a large number of sea turtles (probably Green Turtles, *Chelonia mydas*) died in the vicinity of the Montebello Islands during the year following the October 1952 British 'Hurricane' atomic weapons test.

In 1952, Max Kimber was seaman on board HMAS *Mildura*, a wartime corvette serving as a naval reserve training vessel. The *Mildura* was detailed by the Royal Australian Navy to assist the British Operation Hurricane taskforce establish Britain's first nuclear weapon test on the Montebello Islands, 100 kilometres off the coast of north-western Western Australia. The Hurricane test involved the detonation of a 25 kilo-tonne plutonium device nine metres below water level in the hold of HMS *Plym*, a River-class frigate, moored in 12 metres of water approximately 400 metres off Main Beach on the western side of Trimouille Island, in Bunsen Channel (Figure 1).

The blast, on the morning of October 3 1952, vaporised most of HMS *Plym* and lifted thousands of tonnes of water and sediment into the air. The test was considered 'dirty', even by the standards of the time (Cathcart 1994). The water and sediment raised by the blast was contaminated with fission products from the plutonium device, and much of this fell onto Trimouille Island. Contamination also occurred on islands to the north-west of Trimouille, including North West, Primrose, Bluebell, Carnation, Kingcup, Gardenia and Jonquil Islands (Figure 1). Clearly much of the contamination fell in surrounding waters, both within the Montebello 'lagoon', and into the sea to the north north-west and north-east of Trimouille Island.

The following year, in June 1953, Mr Kimber transferred to HMAS *Fremantle*, a Royal Australian Navy minesweeper. HMAS *Fremantle* and her crew spent two weeks in the Montebello group in October 1953, assisting British scientists in monitoring the

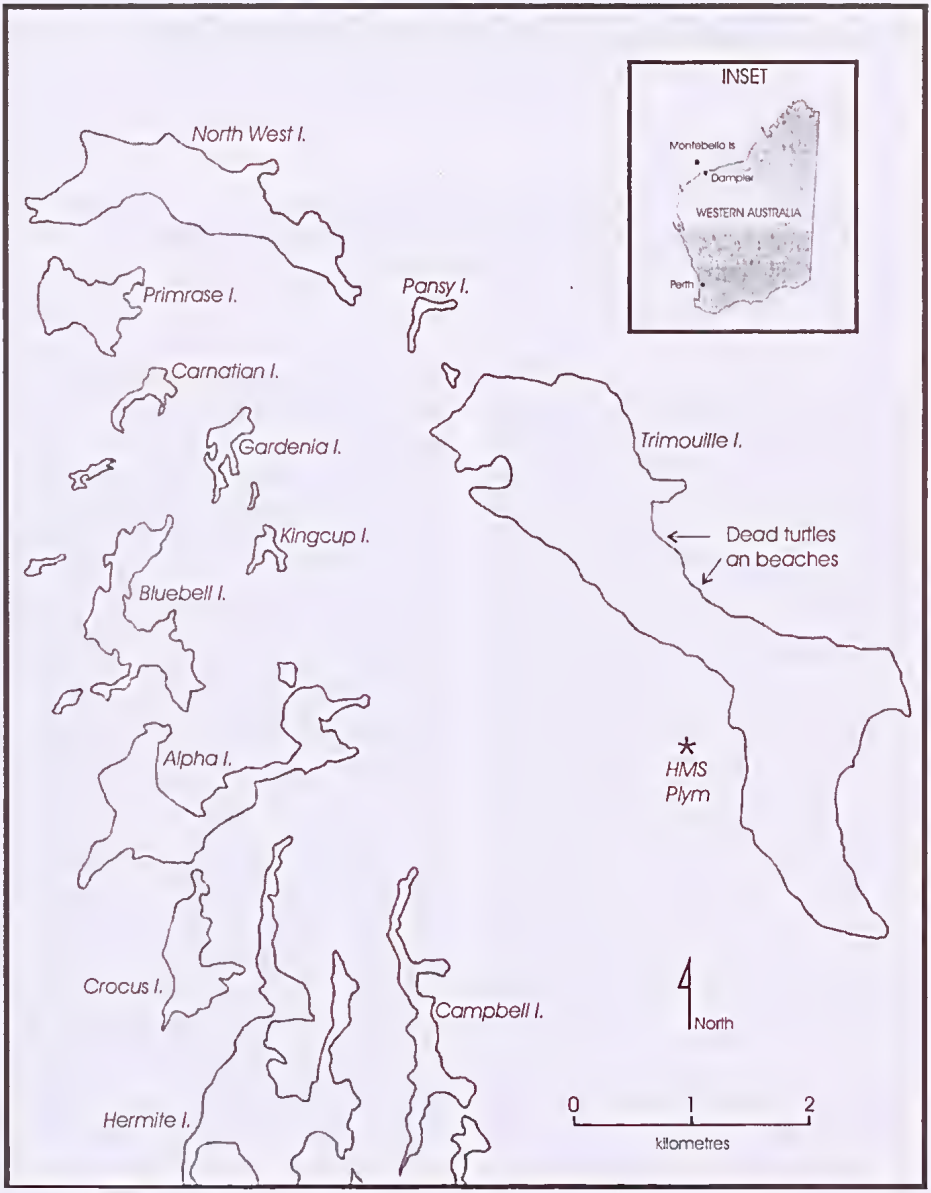

Figure 1. A map of the northern Montebello Islands, showing the approximate position of *HMS Plym* (*) at the time of the British Hurricane nuclear test. The beaches where many dead turtles were observed are indicated by arrows.

aftermath of the Hurricane test. During a day off, Mr Kimber and a colleague sailed around Trimouille Island in a small sailboat. About half way around the island, south of Pitt Point, Mr

Kimber and his companion were forced to land to make repairs to their boat's rudder.

On these beaches, Mr Kimber found large numbers of dead sea-turtles (Figure 1). He stated that for the entire length of the beach (two beaches, each about 500 metres long), dead turtles were 'piled three or four deep, in a layer from six to ten feet (two to three metres) wide'. Turtles of all sizes were represented; some were too large for one man to lift, while others were clearly hatchlings, being 'small enough to fit in one hand'.

Mr Kimber recalls that while the animals had clearly been dead for some time, there was enough rotting material still on the carcases to make them offensive. He estimated that they had been on the beach for some months. They all appeared to be in a similar stage of decomposition, and he saw none were obviously recently deceased.

After repairing their boat, Mr Kimber and his companion resumed their journey, taking a medium-sized carapace (about 0.5 metres long) as a souvenir. They towed it behind the boat in an attempt to clean it. Once back on board HMAS *Fremantle*, the shell was found to be radioactive, and was immediately disposed of overboard.

The presence of hatchlings among the dead turtles indicates that these animals died during or after the 1952–53 summer breeding season (usually between October to February). Their presence on the northern beaches of Trimouille, outside the Montebello 'lagoon' (Bunsen Channel) where HMS *Plym* was destroyed, and the radioactive condition of the shell souvenired by Mr Kimber, indicates that radiation may have been the cause of death, rather than blast effects of the explosion. These beaches are located just 1 – 1.5 kilometres north of HMS *Plym*'s final mooring.

It will never be possible to know the exact numbers of dead turtles that Mr Kimber saw on these beaches. Mr Kimber claimed that he saw 'tens of thousands', but this may have been a personal reaction to what was an overwhelming and distressing sight. However, it would appear that a great many turtles were deposited on these beaches, either dead or dying, at some time in the interval following the October 1952 test and Mr Kimber's visit in October 1953. An estimate of the number can be made from assuming that a two metre section of beach might have contained 10 dead turtles (a two metre length of beach, three metres wide, with turtles of all sizes piled three or four deep). Each beach in this area is approximately 500 metres long, resulting in an estimate of 5000 dead turtles. Mr Kimber has a strong recollection that the smell was very bad, and was still noticeable when offshore in the boat.

Recent aerial surveys of sea turtles on the Montebellos (K. Pendoley, pers. comm.) indicate that the beaches where Mr Kimber saw these dead turtles are those that have the largest aggregations of Green Turtle (*Chelonia mydas*)

nesting anywhere in the Montebellos. Hundreds of animals have been seen within these embayments during recent breeding seasons. Aggregations of Green Turtles begin in October, and continue through the summer. Exploding the 'Hurricane' device in October may well have affected large numbers of turtles aggregating in the area for the coming breeding season. Groups of dead turtles are sometimes seen near nesting beaches – Kellie Pendoley observed 11 mature dead Green Turtles on a beach at Trimouille Island in November 1999, and blowouts on Barrow Island contain the remains of scores of turtles which have become disoriented and perished there over many years. However, these natural phenomena are clearly nothing like that described by Max Kimber.

Mr Kimber does not recall seeing any similar concentrations of dead turtles at other locations during his time at the Montebellos. He does not recall seeing any other species such as dolphin, dugong, fish, sharks or any other animals amongst the turtles on Trimouille Island. Although he recalls a few of the scientific staff showing some interest in the radioactive turtle carapace he souvenired, he does not recall any official interest in the dead turtles on Trimouille. No unofficial photography of the Hurricane test area by RAN personnel was allowed.

Colin Bromfield was also assigned to HMAS *Fremantle* in the 1950s. Mr Bromfield recalled seeing large numbers ('hundreds') of turtle hatchlings moving down to the water on the southern part of Main Beach, close to where HMS *Plym* had been moored, during a visit to the Montebellos in the summer of 1954. This indicates that, despite the immediate effects of the Hurricane test as described by Max Kimber, there were still turtles nesting successfully on Trimouille Island within two years of the test. Mr Bromfield discussed the hatchlings with a British scientist, who offered the opinion that the hatchling turtles may have been advantaged by the tests, since most of the seabirds which might have preyed upon them had apparently disappeared since the Hurricane blast.

The impact of this event on local Green Turtle populations was probably severe. As it takes between 30 and 50 years for a Green Turtle to become sexually mature, recruitment into the breeding population impacted by Operation Hurricane would have occurred after 1982. There is no way to directly measure the impact of the Hurricane tests on the Montebello Green Turtle population, but it is possible that the current population has still not returned to pre-Hurricane numbers.

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ERADICATION OF SILVER PHEASANTS, *LOPHURA NYCTHEMERA* (L) FROM PORONGURUP NATIONAL PARK, WESTERN AUSTRALIA

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ABSTRACT

Long (1981) summarised the establishment and eradication of a small but rapidly increasing population of Silver Pheasants (*Lophura nycthemera* L.) from Porongurup National Park, south-western Western Australia. Nevertheless many people remain unaware of the incident. This note records the event in more detail, particularly the strategy used to eradicate the population, and warns of the potential for this species to establish feral populations in wet sclerophyll forests in the State.

INTRODUCTION

Since European settlement, numerous exotic bird species have established wild populations in Australia (Long 1981). Western Australia (WA) has remained free of the nation's most serious exotic avian pests, European Starlings and House Sparrows, because of vigilance for and eradication of pioneering flocks, particularly starlings, arriving by ship or making their way west across the Nullarbor from South Australia. Never-theless, through deliberate or accidental release, many exotic species have established populations in the State's southwest (Long 1981, Johnstone and Storr 1998). They include species from overseas (e.g. turtle doves, mallard), elsewhere in Australia (e.g. Rainbow Lorikeets, Laughing Kookaburra, Eastern Long-billed Corella) and elsewhere in the State (e.g. Little Corellas in Perth).

Although numerous introductions to WA have failed (Long 1981), there are few examples of exotic species that have been intentionally eradicated. An exception has been the elimination of flocks of sparrows and starlings, effectively eradicating founding populations from WA. However, at a continental scale, this amounts to an example of successful containment and the threat of reinvasion remains because eradication from

Australia is not presently a realistic option.

Another Western Australian example, the eradication of a population of Silver Pheasants (*Lophura nycthemera*; Phasianidae) from the Porongurup Range in south-western WA was briefly reported by Long (1981). Nevertheless, few people are aware of that incident and Long did not report on the methods used. The purpose of this note is to place the details on the record.

METHODS

HISTORY

In 1976, David McNamara of Mt. Barker, Western Australia, reported to the State's National Parks Board (NPB) that Silver Pheasants were living in Porongurup National Park. They had been seen in the area of Devil's Slide, Wansborough Walk and the Tree-in-the-Rock picnic site. These sites are all located along the track that follows the Bolganup Valley and crosses the saddle at its head. McNamara thought that the birds had been released from the Spearwood Gardens Tearooms when the business closed "about three years ago" or were their descendants. On 5 May 1976, Harry Gorringe, then Managing Secretary to the NPB, wrote to George Andrews, National Park Ranger based in Albany (there was no resident ranger in the Porongurup National Park at that time) seeking "comment on the matter and the most feasible method to eradicate the birds" (Gorringe 1976).

Andrews (1976) responded that he had reported one bird on Wansborough Walk "in one of my monthly returns last year" and that the best option for eradication would be shooting. Trapping would be doubtful and poison was "of course out of the question". However, action was postponed so that more information on the numbers and distribution of pheasants in the area could be collected and an effective strategy devised. I undertook that task.

Local residents told me that five silver pheasants had been left to fend for themselves when the tearooms closed and many park visitors told me that they had seen silver pheasants in the area that McNamara reported them, but nowhere else (Start, 1976). Nevertheless most visitor facilities were located in that valley and few people ventured elsewhere. The maximum number of birds seen simultaneously by anyone had been six, a 'silver' cock and five brown birds that were presumed to be hens. All sightings had been in wet sclerophyll forest dominated by Karri (*Eucalyptus diversicolor*) over a dense understory. The NPB, with support from the State's agricultural protection and wildlife conservation agencies, but some local opposition (because the pheasants were seen as a harmless tourist attraction) resolved to eradicate them when the Park's first resident ranger took up duties later that year.

ERADICATION

Ranger Roy Harris commenced control actions in summer, 1977.

From February, he opportunistically shot birds. As there had been an apparent imbalance of sexes favoring females he focused on trying to eliminate one sex, males. In March, he and Start set up six bait stations, three on each side of the valley and several hundred metres from facilities areas. At each station, wheat was scattered over raked ground. The stations were examined for pheasant tracks and the bait was replenished regularly. There was to be no shooting in their vicinity, even if pheasants were sighted.

A funnel trap was constructed at the one bait-station which pheasants habitually used. It was made from chicken-wire and measured approximately 2x2 m by 1 m high. Semicircular holes measuring approximately 30x30 cm were cut at ground level in each side. For about one month pheasants could freely enter and leave the enclosure. During that time, wheat was progressively concentrated within the cage. In late June, when it was apparent that the birds were accustomed to foraging within the enclosure, tapered chicken-wire 'funnels' leading into the enclosure were fixed into each of the four openings.

RESULTS

Table 1 shows details of the pheasants that were removed. No birds have been reported since June 1977. Trapped birds were donated to Perth Zoo.

DISCUSSION

There are two interesting aspects to the incident. Firstly, it is remarkable that a population of large, ground-nesting birds was able to increase from five to at least eighteen in three or four years (and there were unsubstantiated rumors that another ten had been shot before Harris arrived). Many ground-nesting birds have declined in Australia, including the south-west of WA where predation by European foxes and feral cats has often been implicated as a contributory factor (Garnett and Crowley 2000). Foxes and cats are present in the area and there was no predator control program in Porongurup National Park at that time. Many pheasants roost in trees. If the Silver Pheasants did so, the habit would have protected them from cats and foxes at night but incubating birds and chicks would presumably still be

Table 1. Silver pheasants removed from Porongurup National Park in 1977.

Date	Number of birds taken	Method
Feb 1977	1 silver male	Shot
March 1977	2 silver males	Shot
April 1977	2 silver males + 1 brown (? female)	Shot
May 1977	4 birds, sex not recorded	Shot
June 1977	2 silver males + 6 brown birds (? females)	Trapped
TOTAL	7 silver +7 brown + 4? = 18	10 shot + 8 trapped

vulnerable. Moreover, those predators are sometimes active in daylight. The pheasants' ability to avoid predation may have been enhanced by the dense understory associated with the Karri (*Eucalyptus diversicolor*) forest in which they lived.

Secondly, although the actual number of birds of known sex was even (assuming brown birds were females), no observers saw more than one silver bird at a time but on more than one occasion at least six brown birds had been seen in the company of a silver bird. Thus sight records gave a heavily biased impression of the actual sex ratio of the whole population.

The long-term prognosis for the population, had we not intervened, will always be unknown. Long (1981) records many Western Australian examples of initially successful introductions that eventually failed. It is easy to imagine situations in the Porongurup Range that could have caused the demise of pheasants. For instance, an extensive fire in the Karri forest could have increased exposure to exotic predators by destroying cover or forcing them into the adjacent, more open Jarrah (*Eucalyptus marginata*) forest.

Be that as it may, this case shows that silver pheasants have the potential to establish in some wet sclerophyll forests of south-western WA. If they succeeded, the impact of their presence is unknown, but we have learned from bitter experience that many ostensibly benign animals have become economically and environmentally costly pests. In future, Silver Pheasants should be regarded as a potential pest species and any feral birds should be eradicated as soon as possible.

ACKNOWLEDGEMENTS

I am grateful to Roy Harris for his dedication to the eradication of Silver Pheasants from the Porongurup National Park and his family for friendship and support in the field. I am also grateful to John Blythe and Allen Burbidge for their constructive comments on an earlier draft of the manuscript.

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FERALS AT WALGA ROCK

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Walga Rock is a granite monadnock alongside the Cue-Dalaranga Road, 46 km west of Cue. It is one of a group of such granite hills rising from a flat plain which drains westwards to the Sandford and ultimately the Murchison River. The site was of significance to Aboriginal people, who decorated a cave with some very fine rock art. Europeans have also favoured it as a camping spot, and currently it is promoted as a tourist destination. It is included within the Austin Downs station lease.

The site lies in the Eremaean Botanical Province, Austin Botanical District, Upper Murchison Sub-region (Beard 1976). The vegetation of the flats is acacia shrubland to open shrubland over sparse low shrubs and bunch grass (*Aristida contorta*). However, since the rocks harvest water, a different vegetation survives around them. The complex is described as the Norrie Land System in the pastoral survey by Curry *et al.* 1994. The soil slopes gently away from the rock. Dense shrubbery grows immediately adjacent to the rock where drainage is concentrated, succeeded by low bunch grass on the sandy pediment. At Walga Rock, this zone is more or less bounded by the ring road.

On 18 September 1999, I recorded introduced species on or immediately adjacent to the rock, i.e. on the Norrie Land System. Most annual plants were already over, therefore this list is probably far from complete. Nevertheless, it gives some idea of the change which is occurring in natural communities, even in remote areas such as this.

FAUNA

Equus caballus, Horse. Three seen, pushing in among the shrubs to graze the still-green ground herbage. Possibly domestic rather than feral.

Equus asinus, Donkey. Some hoofmarks which could have been donkey were noted.

Capra hircus, Goat. Small group of two nannies, two kids, seen camping and browsing on the rock itself.

Ovis aries, Sheep. Three seen, grazing on claypan grasses in gnammas high on rock. Presumably domestic.

Orycytolagus cuniculus, Rabbit. Common around base of rock.

Mus musculus, House Mouse. Numerous around the main camp site, and probably other bushy areas also.

Vulpes vulpes, Fox. Tracks and scats common. In early evening, a fox cub jumped up onto the bonnet of the vehicle, in order to investigate whether the washing up still carried anything edible.

FLORA

POACEAE

Avena barbata, Wild Oats. Occasional at disturbed campsites, especially on rabbit dung piles.

Pentaschistis airoides, False Hair Grass. Abundant among bunch grass.

Vulpia myuros, Silver Grass. Occasional among bunch grass at water-gaining sites, close to rock and in washways.

ASTERACEAE

Hypochaeris glabra, Flatweed. Common at edge of shrub patches.

Sonchus oleraceus, Sow Thistle. Occasional in deep shade.

BRASSICACEAE

Sisymbrium orientale, Indian Hedge Mustard. Single plant noted in fenced area around art site – removed and destroyed after observation.

CARYOPHYLLACEAE

Silene ?nocturna, Catchfly. Occasional at edge of shrub patches.

CONVOLVULACEAE

Cuscuta epithymum, Lesser Dodder. Widespread, abundant parasite on ground layer plants, including bunchgrass and annuals such as *Angianthus tomentosus*.

POLYGONACEAE

Emex . australis, Doublegee. Common at all campsites.

Rumex vesicarius, Ruby Dock. One dense infestation at main camp site, single plants scattered elsewhere, along tracks and among bunch grass.

PRIMULACEAE

Anagallis arvensis var. *caerulea*, Blue Pimpernel. Common under dense shrubbery.

SOLANACEAE

Solanum nigrum, Blackberry Nightshade. Common in dense shade under shrubs close to rock.

DISCUSSION

This rock has mostly bare gnammas and no herbfields, unlike similar granites in the Wheatbelt. This sparsity of plants must be related to the aridity and the high rock temperatures which will be reached in summer since, even on grazed farmland granites, some low vegetative cover usually remains on gnamma floors. However, it is noticeable here that the hooves of sheep and goats have cracked the surface crust on gnamma floors and that this leads to wind erosion of the fragile soil

accumulation beneath. Macropod feet do not have as drastic an effect, therefore it is possible that, in the hundred or so years since pastoral settlement, the flora (and presumably fauna) in the gnammas has become severely depauperate. Evidence from scats shows that in wetter seasons rabbits also feed on the outcrop, and this must exacerbate the degradation.

Foxes must have had a severe effect on any small to medium sized native mammals which once occurred in the area, and also on lizards and frogs – although it is possible that they have merely replaced the dingo.

Apart from the False Hair Grass, all the plants are likely to have been brought to the site by fauna, either externally or internally. At the moment they are a relatively minor component of the flora. The greatest threat to the integrity of the site would appear to be Ruby Dock and Paterson's Curse (*Echium plantagineum*, Boraginaceae), both of which are highly invasive and totally alter the character of the vegetation communities they infest. The latter does not yet occur here (nb: as at date 18/09/1999) although there is a large infestation at Austin Downs station, 36 km east. It is likely to be transported by vehicles, and to appear first at water-gaining sites along track edges.

At the moment, a determined spraying effort could control – even eliminate – Ruby Dock, while annual checkups could prevent the invasion of Paterson's Curse. However, since there is no authority really responsible for the site, and everywhere there are only limited resources available for weed control, it is difficult to know how this could be achieved. Perhaps this example could be presented to the body responsible for implementing the State Weed Plan, with a request that a trust fund be set aside and a 'flying squad' trained and then employed to tackle such weed problems in remote localities.

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BODY MARKINGS OF THE WHALE SHARK: VESTIGIAL OR FUNCTIONAL?

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ABSTRACT

The whale shark's distinctive body markings are similar to those of other orectolobiform sharks. These markings likely conceal their sluggish, bottom-dwelling relatives through disruptive colouration. It is argued here that the whale shark's body markings similarly function to camouflage them in their pelagic environment. The whale shark's countershaded colouration eliminates the optical appearance of relief against its visual background. Disruptive patterns resembling elements common in its environmental background break up the whale shark's outline. Other possible functions for the whale shark's markings are considered, including: radiation shielding, intraspecific communication (species recognition, sex recognition, postural displays, schooling coordination), and interspecific communication (aggressive mimicry). However, they are either discounted or evidence substantiating these functions is found to be lacking.

INTRODUCTION

Prior to 1986, there had been only 320 reported sightings of the whale shark, *Rhincodon typus* (Orectolobiformes, Rhincodontidae), worldwide (Wolfson 1986). Today they can be reliably encountered and studied in several locations around the globe (Compagno 1984; Colman 1997; Eckert and Stewart 2001), including Ningaloo Reef, Western Australia. Consequently, there is increasing research interest into the biology of whale sharks. In addition to being the world's largest living fish and possessing a distinctly unique body form, one

of the whale shark's most striking features are its body markings, the function of which has only been briefly speculated about in the literature. The purpose of this paper is to review the possible relevance of these markings to the life history and biology of the whale shark.

Despite their being among the most abundant large animals on earth, our knowledge of the behaviour of sharks in the wild is almost non-existent. Myrberg (1976; 1991) and Gruber and Myrberg (1977) have recognised the difficulties arising from studies of sharks in captivity and in the field. For most species, captive environments cannot be created to adequately simulate natural settings to ensure 'natural' behaviour. Field studies are often even less favourable. Many species are fast-moving or far-ranging, while some are dangerous to observers (Johnson and Nelson 1973; Myrberg *et al.* 1972), leading to logistical and methodological constraints that combine to make the cost and effort of research prohibitive (Myrberg 1991). As a result, scientific knowledge of the behaviour of sharks lags decades behind that known about large terrestrial animals.

As these problems will likely persist into the foreseeable future, alternative ways of interpreting the adaptive roles of shark structures and features must be considered. One accepted approach to the study of shark behaviour is based strictly on anatomical considerations, supplemented with inference about their functional and behavioural relevance (Myrberg 1991). In essence, logical inference and circumstantial evidence can be meaningfully applied to the interpretation of morphology. Such intuitive methods can provide ethologists with testable hypotheses that potentially explain a suite of observations under a logically consistent theoretical model. However, interpretations divorced from their normal environmental context (including social dynamics, prey behaviour, oceanographic conditions, etc.) should be applied cautiously until such time that they can be supported by direct observation and experimentation.

DISCUSSION

BODY MARKINGS

Dorsally, the whale shark's basic colouration is blue, grey, or brown, while ventrally it is white (Last and Stevens 1994). Overlying this dark dorsal background is a distinctive checkerboard pattern composed of pale spots, vertical bars and horizontal stripes (Figure 1). At birth, all orectolobiform sharks have patterns of bars, often in the form of wide bands or saddles, and spots. However, in most species these markings fade or change with age (Dingerkus 1986). With the exception of the whale shark, all orectolobiform sharks are primarily benthic. Benthic or bottom-dwelling sharks often possess bold body markings that most likely provide camouflage through disruptive colouration (Bass 1978). Within the order Orectolobiformes,

Figure 1. Adult whale shark, TL ca. 10.0 m.

Figure 2. Neonate whale shark, TL ca. 0.58 m.

Stegostoma is regarded as the primitive sister taxon of *Rhincodon* (Dingerkus 1986; Compagno 1988). The zebra shark, *Stegostoma fasciatum*, is thus the whale shark's closest extant relative. Juveniles possess vertical yellow bars and spots that break the background colouration into dark brown saddles (Compagno 1984). When zebra sharks are between 50 and 90 cm TL, these saddles break up into small spots, which become more evenly spaced as the animal grows.

ONTOGENETIC CHANGE IN BODY MARKINGS

The ontogenetic change in pigmentation pattern in most orectolobiform sharks raises some important issues. The change may be related to the different habitats used by neonates/ juveniles and adults. Neonate/juvenile zebra sharks seem to live primarily in water deeper than about 50 m (R.A. Martin, pers. obs.). Such depths may represent a relatively predator-free refuge for the young and this pattern partially explains why juveniles are so rarely collected, and even more rarely seen by recreational divers, compared with adults. The bold zebra-pattern may function as disruptive colouration, visually concealing the pups from potential predators by breaking up their bodies into a series of irregular shapes against the backdrop of benthic cover. The adults of this species are most commonly encountered by divers in sandy areas around reefs at depths of less than 30 m. Young tassled wobbegongs, *Eucrossorhinus dasypogon*, less than 1 m TL are orange-brown in colour and typically inhabit water shallower than 10 m and are thus often encountered by divers. Larger individuals become increasingly pale, the largest at 3 to 4 m TL are yellowish-white, and typically inhabit ever deeper water as they grow (down to a depth of at least 40 m) (R.A. Martin, pers. obs.). Similarly, young nurse sharks, *Ginglymostoma cirratum*, are pinkish brown with small brown or blue spots, while adults are a uniform chocolate brown and typically inhabit much deeper water than juveniles (Carrier 1991; R.A. Martin, pers. obs.). Whale sharks are born with markings similar to those of adults (Figure 2). Since whale sharks are not thought to change their pelagic habitat substantially from neonate to adult, there may be no selective pressure to change their pigmentation pattern as they age.

Cott (1940) uses the 'ontogeny recapitulates phylogeny' argu-ment to account for the presence of stripes and spots in the young of many open country predatory cats, including as lions, pumas and lynxes. The functional relevance of these markings is questioned in cubs that are sheltered in dens or holes. Cats inhabiting wooded surroundings, such as leopards, pumas and ocelots, generally retain or intensify these patterns in adulthood. Cott (1940) suggests that stripes and spots may represent a primitive pattern in cats, accounting for their presence in the young of open country species on ancestral rather than ecological grounds. This rather

rigid application of Haeckel's Law could also be applied to the presence of bars and spots in orectolobiform sharks that lose these patterns. But it raises the question of why these markings are retained in adult whale sharks.

VESTIGIAL

Are the whale shark's distinctive pattern of body markings vestigial with no modern function? Their pigmentation pattern bears evidence to its phyletic relationship with similarly marked benthic ancestors. However, the whale shark is a pelagic fish that would not be viewed against a benthic substrate. In classical Darwinian natural selection, retention of a characteristic would be favoured if it enhances survival and/ or reproductive success or is at least not deleterious in any way. Alternatively, do the whale shark's body markings reflect an adaptation to its modern pelagic lifestyle? The examination of this question forms the substance of the remainder of this discussion. Other possible explanations for the whale shark's body markings include:

CONCEALMENT

Many animals employ the use of cryptic colouration to conceal themselves against their visual background. The degree of crypsis and the quality of concealment are usually proportional with the intensity of predation pressure (Endler 1978). There is evidence to suggest that young whale sharks suffer significant mortality from predation. Many of the whale sharks observed at Ningaloo Reef exhibit healed bite marks and/ or have pieces missing from their fins (S.G. Wilson, pers. obs.). Neonate whale sharks have been found in the stomachs of a blue shark, *Prionace glauca* (Kukuyev 1996), and a blue marlin, *Makaira mazara* (Colman 1997).

To rapidly reach a size large enough to avoid predation, many sharks put their energy into somatic growth, delaying reproduction until relatively late in life (Stevens and McLoughlin 1991). Whale sharks reach sexual maturity when ca. 9.0 m TL and aged in their late 20s (Wintner 2000). A female whale shark harpooned off the coast of Taiwan in 1995 contained 301 embryos (Joung *et al.* 1996), more than double the number of embryos reported in any other species of shark. Such high fecundity may represent a mechanism to compensate for the delay in reproduction made to achieve a large size. Large litters would also offset high neonate and juvenile mortality resulting from predation.

In the pelagic habitat of the whale shark, visual recognition by a predator would likely be achieved via any of three cues: colour, relief and outline (Cott 1940). It is the elimination of these telltale signs that is the key to effective camouflage in the whale shark. To pass unnoticed in its environment, the whale shark's colouration must match that of its visual background. Tropical seas are generally low in particulate matter and plankton, making them transparent to light of short wavelengths and characteristi-

cally blue (McFarland and Munz 1975). However, a uniform blue colour would not allow it to avoid detection. Colour and brightness of the visual background vary considerably depending on the line of sight of the observer. This would be compounded by the unequal reflection of light, giving the impression of relief through the presence of light and shadow (Cott 1940).

Countershading

Countershading utilises differences in dorsoventral colouration to allow an animal to blend in with its visual background (Cott 1940). A countershaded fish is coloured dark dorsally and light ventrally, visually matching the dark ocean depths when viewed from above and the bright surface when viewed from below. When viewed from the side, countershading eliminates the perception of relief by counteracting the effects of dorsal lighting and ventral shading. Countershading effectively renders the bearer optically flat, destroying the appearance of depth and decreasing the likelihood of visual detection. Many pelagic fishes are laterally compressed to minimise detection from above or below (McFarland and Munz 1975). Consequently, their dorsal colouration fades gradually down their flanks until lightly coloured on their ventral surfaces. The whale shark's more fusiform cross-section, dorsoventrally flattened anteriorally, favours a more abrupt transition.

The use of graded tones of a given colour is not the only way of achieving countershading. In obliterative countershading, certain patterns viewed from a distance produce the same effect. A pattern consisting of both light and dark markings, such as stripes, bars or spots, observed from or beyond what is termed the 'blending' distance blends to form a uniform half-tone. If the proportion of light to dark in the pattern increases, the colour tone will lighten. In this way, it is possible to produce a flat tone ranging from dark to light as one passes from the dorsal to ventral aspect. This effect is most evident in the whale shark at the abrupt dorsal/ ventral colouration interface. But what advantage does the use of blended patterns have over graded tones of uniform colour? To a closer observer these conspicuous patterns would be clearly visible. It is not incompatible that the same pattern could be used to both increase and decrease visibility (Denton and Rowe 1994). A pattern perceptible to nearby observers would not necessarily be resolved by distant predators or prey. These patterns may be used to visually deceive closer observers by other mechanisms. Furthermore, they may be used to communicate information to other whale sharks and/ or communicate misinformation to predators and prey.

Disruptive colouration

Under ideal conditions, background matching colouration combined with effective countershading renders an animal almost

invisible (Cott 1940). However, the visual background of most animals is constantly changing. An animal that is cryptically coloured in graded tones of a given colour would stand out as a patch of uniformity against a dynamic background of varying brightness and/ or colour. Especially so in an animal as large the whale shark. It is this continuity of surface and the appearance of an outline that leads to recognition. Thus, for effective concealment it is essential that the outline be obliterated. This is achieved successfully in many animals by harnessing the optical properties of disruptive patterns. Disruptive patterns contain some elements that closely match the background and others that stand out as distracting marks to disrupt surface continuity. Strongly contrasted tones, such as very light patterns on a dark background are most effective. Since the disruptive elements draw the attention of the observer, they should pass for part of the visual background.

Many countershaded marine fishes superimpose patterns of stripes, bars and spots over their cryptic background colouration (Cott 1940). Widespread in pelagic teleosts, such as mackerel, tunas, and marlin, are dorsal vermiculations that grade into vertical bars on the flanks (McFarland and Loew 1983). Whale sharks and young tiger sharks, *Galeocerdo cuvier*, possess these markings, which appear to mimic wave-induced patterns of sunlight. They likely function to reduce surface continuity by breaking up the shark's form into meaningless shapes. The reticulations are more consistent with the visual background than the surface upon which they appear. Viewed from an upwards angle against flickering surface water they appear to be a part of the natural environment. When observed against the backdrop of the deep ocean, they may be perceived as flickering shafts of underwater sunlight. The spots create the impression of a series of small objects resembling a school of fish. It has already been argued that countershading renders the bearer optically flat, causing an observer to look 'through' the animal. The combination of countershading and disruptive colouration used by the whale shark draws the attention of an observer through the animal to what appears to be a series of small objects moving in the midst of flickering beams of light. The outline passes unnoticed.

Flicker fusion

It has been established that the whale shark's lightly coloured patterns would be highly conspicuous to a predator at close distances. Visibility may be further enhanced by the continuous movement of the animal through the water. Upon sighting a predator, a young whale shark would likely attempt to flee with rapid burst of speed. Such a rapid movement across the predator's visual field may blend its background colouration and the superimposed patterns into a uniform colour. Whale shark

pups would quickly transform from being highly visible to indistinguishable against their background. To the predator, the visual stimulus would be similar to that of a slow moving whale shark viewed from beyond the blending distance (indistinguishable against its visual background). In this case, rapid movement rather than distance would blend the patterns.

This form of cryptic concealment, known as 'flicker fusion', is well documented in many species of snakes (Pough 1976; Jackson *et al.* 1976). During rapid escape movements, the conspicuous black, red and yellow vertical bands of coral snakes are reported to blend together into a uniform dark brown colour, matching their normal visual background. It is difficult to imagine that young whale sharks would be capable of achieving the speed necessary to induce flicker fusion in large predatory sharks or teleosts. Regardless, rapid movements by a strongly patterned animal may cause confusion in a predator, creating the impression that the animal is moving faster than it really is (Deiner *et al.* 1976). McFarland and Loew (1983) suggest that the vertical stripes may serve to confuse predators in another way, by disrupting their fixation. Viewed against flickering surface waters, these patterns may be alternately visible and invisible in a fish that constantly changes direction.

RADIATION SHIELDING

Whale sharks spend a significant proportion of time in shallow surface waters, possibly exposed to high levels of ultraviolet radiation (Colman 1997). For many organisms, exposure to high-intensity solar radiation is detrimental (Harm 1980; van Weelden *et al.* 1986), but melanomas and dermal carcinomas are unknown in sharks (Stoskopf 1993). Most of the dermal tumors found to date on elasmobranchs have been fibroid in nature, most likely attributable to foreign body intrusions (C. Lowe, pers. comm.). Extensive exposure to ultraviolet-B radiation can lead to the formation of thymine dimers, known to cause several types of dermal carcinomas or neoplasia in other fishes and humans.

Animals shield themselves by pigmentation that protects ultraviolet sensitive tissue or by seeking microhabitats protected from ultraviolet light (Burtt 1981). Lowe and Goodman-Lowe (1996) documented increases in the integumental melanin of juvenile scalloped hammerhead sharks, *Sphyrna lewini*, in response to increases in ultraviolet radiation, illustrating for the first time 'tanning' in an aquatic vertebrate. However, pronounced darkening is reported to be a common reaction to capture stress in juvenile lemon sharks, *Negaprion brevirostris*, maintained in an indoor pool at the University of Miami (B.M. Wetherbee, pers. comm.).

The dark background of the whale shark's countershaded dorsal surface could clearly help shield underlying tissue from the harmful effects of radiation (Myrberg, 1991). Yet one must

question why the whale shark possesses white regions directly adjacent to darker melanic regions. The whale shark would likely expose unshielded areas to radiation as well as shielded regions each time it entered shallow water. This suggests that the presence of two adjacent regions of pigmentation have greater benefit than either singly (Myrberg 1991).

Another shark that might need such protection is the blacktip reef shark, *Carcharhinus melanopterus*, a resident of shallow reef flats that often swims with its first dorsal fin out of the water (Myrberg 1991). The melanin at the tip of this fin would clearly shield the underlying tissue from radiation damage, yet just below this melanic region is an extremely white band. Again, this area would also be exposed to radiation, raising doubts that radiation shielding is the primary, or even a major, function of pigmentation patterns in shallow-water sharks.

INTRASPECIFIC COMMUNICATION

A few shark species appear to have the ability to transfer information to achieve certain social functions, such as readiness to fight or mate (Myrberg 1991), and it seems reasonable that most, if not all, sharks share this ability to some extent. Such communication requires two participants: a signal sender and a signal receiver (Hopkins 1988). These messages are usually visual, the optical signal consisting of motor patterns and/ or body markings.

Species recognition

Coloured fin tips are believed to facilitate species recognition in many species of pelagic requiem and hammerhead sharks (family Carcharhinidae),that appear otherwise superficially similar to sympatric species (Myrberg 1991). Considering the whale shark's large size and distinctive body form, it could be argued that they would be able to achieve species recognition without the use of distinctive body markings. The Greenland shark, *Somniosus microcephalus*, and the great hammerhead shark, *Sphyrna mokarran*, are also very large and have unique body forms, yet lack obvious fin or body markings. However, the bluntnose sixgill shark, *Hexanchus griseus*, the megamouth shark, *Megachasma pelagios*, the basking shark, *Cetorhinus maximus*, the white shark, *Carcharodon carcharias*, and the tiger shark, are also very large with distinctive, if not unique, body forms. Yet all have distinctive body and/ or fin markings (less distinct in large tiger sharks). This suggests that the situation regarding distinctive markings in sharks is rather more complex than simply resulting from a need for intraspecific recognition.

Sex recognition

Body and fin markings are not sex specific in any species of shark and, therefore, do not aid in the sex recognition process (Myrberg 1991). Rather, there is evidence to suggest that female pheromones are involved pre-copulatory attraction and sex recognition in

some species of elasmobranchs (Bass 1978; Johnson and Nelson 1978; Luer and Gilbert 1985; Demski 1990; Gordon 1993).

Postural displays

Intraspecific competition is exhibited when two or more individuals of the same species simultaneously demand use of a limited resource (Wilson 1975). Contest competition results when one competitor actively prevents another's access to resources through aggression or displacement, allowing that individual to obtain a greater share of resources. Access to the resource is usually established through agonistic behaviour that rarely takes the form of fighting (Klimley *et al.* 1996). Competitors display exaggerated motor patterns that demonstrate the unease of the displaying individual to the presence of another and its capacity to inflict harm should the competitor remain. The signaler consequently gains an advantage if the recipient heeds the message and withdraws (Burghardt 1970). Documented examples of agonistic displays in sharks include the exaggerated swimming display of the gray reef shark, *Carcharhinus amblyrhynchos* (Johnson and Nelson 1973), and tail slapping and breaching in the white shark, *Carcharodon carcharias* (Klimley *et al.* 1996). Similar behaviours are also known in the smooth dogfish, *Mustelus canis* (Allee and Dickinson 1954), the bonnethead shark, *Sphyrna tiburo*, and the blacknose shark, *Carcharhinus acronotus* (Myrberg and Gruber 1974), the scalloped hammerhead shark, *Sphyrna lewini* (Klimley 1985), and others. In short, agonistic displays are widespread among sharks.

It is likely that whale sharks also use postural displays to establish dominance hierarchies during feeding and mating aggregations. A recent observation of an interaction between two whale sharks in the Philippines may provide some evidence for this hypothesis. In this encounter, the larger of the two sharks banked towards the smaller one, forcing it into tightening circles (G.L. Kooyman, pers. comm.). Eventually the smaller whale shark fled the area. During this display, the larger animal presented its competitor with its dorsal surface, the location of the markings in question. Further observations of social displays in whale sharks are needed before any conclusions can be made of this possible function.

Schooling coordination

Schooling would provide a number of benefits to whale sharks, particularly during the first years of their lives. A school of neonate sharks would have many times the number of eyes and other senses to detect predators than would a solitary individual. Predators would be presented with a visually confusing cluster of constantly milling bodies bearing bold markings, making it difficult to single out an individual at which to strike. When a predator attacks, chances are it will be someone else. Furthermore, there are hydrodynamic advantages to be gained

by being a member of a school. Schooling in fishes is coordinated using both vision and the acoustico-lateralis system (Partridge and Pitcher 1980). The dark bars on the sides of many schooling fishes allow individuals to fixate on the side of a neighbour and coordinate polarised movement (Shaw 1962; Denton and Rowe 1998).

The limited information on whale shark parturition obtained from the single gravid female captured off Taiwan in 1995 seemed to indicate that whale sharks most likely give birth to their young over a protracted period (Joung *et al.* 1996). Larger size classes of embryos were free of their egg cases and presumably ready to be born, while smaller individuals were still in their cases and clearly not yet ready. However, recent studies on nurse sharks, *Ginglymostoma cirratum*, suggest that more developed embryos are retained until the less developed embryos mature, resulting in the litter being born at more or less the same time (C.A. Manire and J.C. Carrier, pers. comm). As each of the nine neonate whale sharks recorded in the literature were taken pelagically (Wolfson 1983; Kukuyev 1996; Colman 1997), it is reasonable to believe that whale sharks are born more-or-less at the same time in the open ocean.

Whale shark pups have a relatively low Reynolds number when compared with their mother. They also inherit a basic structure featuring an overwhelming predominance of white myotomal muscle which responds to sustained high activity by relying on anaerobic glycolysis as an energy source (accumulating a lactic acid debt) (Kryvi and Eide 1977). These factors suggest that neonate whale sharks would have difficulty keeping up with their mother for any extended period. However, a recent observation of an adult whale shark accompanied by 16 juveniles indicates that this may not be the case (Pillai 2001). Whale shark pups may cluster together for both safety and to reduce swimming effort, using their bold body markings as visual cues to coordinate schooling behaviours such as parallel orientation.

INTERSPECIFIC COMMUNICATION

Communication is not restricted to members of the same species. Most ethologists include cases of signal exchange between members of different species. Body markings are used here to assist the sender to transmit misinformation, by concealing the sender and at the same time increasing its conspicuousness. In this scenario, the signal is optical, the sender is the shark and the receiver is the shark's prey. The effect of this visual signal depends on the environmental variables that influence its appearance and on the characteristics of the photoreceptors of the receiver.

Aggressive mimicry

Aggressive mimicry provides a predator with the opportunity to get much closer to a victim than otherwise would be the case (Myrberg 1991). To attain this

proximity, the predator mimics a signal that is normally attractive to, or at least is not avoided by, the intended prey (Edmunds 1987). Myrberg's (1991) examination of the functional relevance of the huge white tipped fins of the oceanic whitetip shark, *Carcharhinus longimanus*, clearly demonstrates this concept. His 'spot-lure' theory describes how the silhouette of a nearby oceanic whitetip is easily seen; but from a distance the body's silhouette becomes indistinct and only the moving white-tipped fins ('spots') remain visible. An observer would see a 'pack' or a 'school' of small, white objects moving closely together at a distance. Oceanic whitetips are known to prey upon some of the fastest oceanic predatory fishes and it is unlikely they could chase down or sneak up on them in open water. Since many small prey fish are lightly coloured and move in schools, it is postulated that predatory fish would likely investigate by moving toward such 'prey'. The scenario is that the whitetips spots lure faster moving prey to a distance where the shark's rapid acceleration could overcome veering by the predatory fish. Evidence is also provided that young oceanic whitetips hide their lures, as they may attract predators, by wearing a transitional 'costume' of black tipped fins.

The optical effect described in oceanic whitetip sharks is not apparent from in-water observations of whale sharks. The first visual cues to register, signaling the location of an approaching whale shark, are the outline of its oval mouth and the large caudal fin. The whale shark's body only seems to resolve from the visual background after one recognises these cues and strains to see the rest of the fish. As the animal gets closer still (within the 'blending distance'), the shark's unique body markings become evident.

Whale sharks feed on a variety of planktonic and nektonic prey, including small crustaceans and small schooling fishes (Compagno 1984; Last and Stevens 1994). One of the primary functions of schooling in crustaceans and small fish is to protect its individual members from predation. This strategy is effective against predators taking individuals one at a time (e.g. predatory fish, seabirds), but would appear to be ineffective, if not detrimental, against bulk-feeding predators (Sharpe and Dill 1997) such as the whale shark. The whale shark's suction-feeding mechanism is quite limited in the amount of seawater it can process per unit of time and consequently whale sharks must target dense concentrations of prey (Compagno 1984). In coastal waters off Ningaloo Reef, whale sharks appear to feed primarily on swarms of the tropical euphausiid *Pseudeuphausia latifrons* (Taylor 1994; Wilson and Newbound 2001).

The importance of whether the whale shark's outline or its spots are visible first is questionable from the perspective of their small schooling prey. Rather, the visual stimulus for the prey at

closer distances (within striking range) should to be considered, as it is at this distance that the group would collectively flee. Schooling zooplankton and fishes, observing an approaching whale shark, may see a 'pack' or a 'school' of small white objects moving closely together. It is reasonable to consider that they might respond to this stimulus by either doing nothing, or by moving towards the 'school' with the intention of fusing. In maximizing school size, individual members would be accorded greater protection from predation. Laboratory studies have shown that both schooling crustaceans and fishes will move towards and merge or fuse with another school when presented with the opportunity (Hamner *et al.* 1982; Pitcher and Wyche 1982).

White objects reflect maximally all wavelengths of the visible spectrum, and are chiefly illuminated by daylight that has traveled the direct path from the surface to the object and whose radiance is then reflected into the eye of an observer. Of course, the nearer the object is to the surface, the greater the illumination and the more intense the reflection. The background water contains scattered light that has traveled a longer path and hence has a narrower spectral radiance curve. The broader spectral radiance reflected off the whale shark's spots would also more than likely contain those wavelengths that are absorbed by the various visual pigments possessed by the retina of an observer, enhancing the relative brightness of the spots. If the observer possesses retinal pigments sensitive to longer wavelengths (colour vision), the 'lures' will be further enhanced by stronger contrast against the background water (McFarland and Munz 1975).

It should be questioned at this point whether it would be necessary for the whale shark to use aggressive mimicry, as it is much more mobile than its prey. Due to low Reynolds numbers, zooplankton are virtually glued in place by viscous and electrostatic forces. Rapid avoidance is not much easier for small baitfishes, which have to swim much harder than a whale shark to overcome viscous forces. Additionally, suction-feeding would significantly extend the 'striking range' of the whale shark and could surely overpower the feeble swimming abilities of most prey.

CONCLUSION

In reviewing the body markings of the whale shark, we conclude that they function primarily to conceal the animal in its pelagic habitat. Countershading eliminates the appearance of solidity while disruptive colouration disrupts surface continuity, carrying the eye of the observer through the optically flattened surface of the whale shark's body to patterns that are consistent with the animals open ocean habitat. The bold pigmentation pattern of whale sharks may also be adaptive in neonates by facilitating visual coordination of schooling in the open ocean, thereby further reducing each

individuals swimming effort and vulnerability to pelagic predators. We acknowledge that without experimentation it is difficult to separate actual functions from possible functions in an animal about which so little is known.

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THREE RECENT RECORDS OF PIED CORMORANT (*PHALACROCORAX VARIUS*) PREDATION ON SILVER GULL CHICKS (*LARUS NOVAEHOLLANDIAE*) IN WESTERN AUSTRALIA

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ABSTRACT

Pied Cormorants (*Phalacrocorax varius*) have been recorded throughout coastal areas and inland waters of Australia eating a variety of fish and a few crustacean species using pursuit-diving. This paper records three isolated events where Pied Cormorants were observed eating live Silver Gull (*Larus novaehollandiae*) chicks or attempting to remove chicks from gull nests on Penguin Island, Western Australia.

INTRODUCTION

Penguin Island is a coastal limestone island situated 42 kilometres south-west of Perth, W.A., and 600m west of Mersey Point in Shoalwater Bay, Shire of Rockingham (Dunlop *et al.* 1988). Pied Cormorants roost on the eastern side of the northern most point of the island between February and July. Silver Gulls nest on the southern and northern plateau of Penguin Island. Laying usually begins in late March, early April and continues until November. Their laying pattern is consistently trimodal with peaks in autumn (April), winter (June) and spring (August–September). The main laying peaks are followed by a pronounced trough in newly initiated clutches (Dunlop 1986), with peaks becoming progressively less synchronised throughout the protracted season (Wooller and Dunlop 1979). There is a pronounced peak in fledglings in early June (Dunlop *et al.* 1988).

Pied Cormorants are underwater pursuit-divers that use their feet to reach the bottom where they search for their prey (Schreiber and Clapp 1987). At various sites within Western Australia, Victoria, South Australia and New Zealand, Pied Cormorants have been reported eating a variety of fish and crustacean species all taken by diving, using their feet for propulsion (for review see Marchant and Higgins 1990). A Western Australian study found the feeding pattern of three

common cormorant species, the Little Pied (*P. melanoleucos*), Little Black (*P. sulcirostris*) and the Pied Cormorant to be opportunistic but restricted to a variety of slow-swimming benthic-feeding fish and crustaceans (Trayler *et al.* 1989). An early paper (Storr 1965), on the birds of Rottnest Island in Western Australia reported the possibility of Pied Cormorants taking the ducklings of the Australian Shelduck (*Tadorna tadornoides*), although this was not actually observed.

OBSERVATIONS

Record No. 1

On 25 May 2000, a single Pied Cormorant was seen walking into the Silver Gull breeding colony on the southern plateau of Penguin Island. It approached a nest within 10m of the rocks where it had previously perched and removed a single gull chick. The cormorant held the chick in its beak while it moved about 2m away from the nest, then swallowed the chick whole. This action was repeated with a second chick from the same nest. The cormorant then flew away from the area. During the cormorant's attack, only nearby gulls attempted to defend their nests, using aerial dive-bombing and vocalisations.

Record No. 2

On 30 May 2000, a single Pied Cormorant entered the gull colony on the southern plateau of the island. As it walked amongst the nests, several attempts were made to take chicks by reaching into the gull's nests. Defence by the gulls was apparently too strong on this occasion and the cormorant flew from the colony without success. Again, only those gulls from directly adjacent nests attempted any form of defence against the cormorant.

Record No. 3

On 28 September 2000, a Pied Cormorant was observed flying over the gull colony at the northern end of the southern plateau. The cormorant made several low passes before landing and removing a gull chick. The chick was held in the cormorant's beak while it flew over the water and was then swallowed whole once the cormorant had landed on the water. The gulls responded by aerial attacks on the cormorant, continuing while the cormorant flew over the water and only ceased once the chick was eaten. The gulls appeared to be making attempts to snatch the chick off the cormorant in the same way that they would attack another gull carrying a large piece of food.

In the past, Pied Cormorants have been observed roosting on Penguin Island and approximately 400–500 pairs have nested on Shag Rock, 600m north of the island (Dunlop *et al.* 1988). Although no recent estimates of population size have been made, cormorants have been recorded nesting and successfully raising chicks on Penguin Island since at least 1999 (personal observation). The breeding season of the Pied Cormorant in this region extends

from February to July, coinciding with the first two observations of predation on gull chicks during May. The third observation, in September, did not however coincide with the cormorant's breeding season.

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THE WESTERN SPINY-TAILED SKINK, *EGERNIA STOKESII BADIA*: DECLINING DISTRIBUTION IN A HABITAT SPECIALIST

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ABSTRACT

The Spiny-tailed or Gidgee Skink, *Egernia stokesii*, has two western subspecies; one of which, *Egernia stokesii badia*, has declined in distribution and abundance because of habitat disturbance and is currently listed as threatened. This study examined all known locations of *E. s. badia* in the Western Australian Wheatbelt to determine its current status. Results show that it is still found over a large part of its previously known range in the eastern part of the northern Wheatbelt, but it has declined or disappeared from most localities in the central Wheatbelt. Reintroduction to previously occupied sites from populations occupying threatened localities (abandoned buildings, farm sheds, etc.) could be undertaken if suitable habitat (e.g. old hollow logs) is established or available at translocation sites and members of family groups are relocated together.

INTRODUCTION

The Spiny-tailed Skink or Gidgee Skink, *Egernia stokesii* (Gray 1845), is a large, stout, live-bearing skink up to 28 cm long with short dorsal spines and longer tail spines. It has several geographically separate and morphologically distinct populations and currently two subspecies are recognized in Western Australia (Aplin and Smith 2001). The nominate subspecies, *E. s. stokesii*, occurs on islands in the Pelsaert and Wallabi Groups, Houtman Abrolhos, and on Useless Loop in Shark Bay, while the distribution of *E. s. badia* (Storr 1978) is focussed in the central and northern Wheatbelt with two known outlying localities in the central Carnarvon Basin and populations on Dirk Hartog Island and near Denham in Shark Bay. A previously recognized third subspecies in Western Australia, *E. s. aethiops* (Storr 1978), described from

Baudin Island in the Freycinet Estuary, appears most closely related to the nominate *E. s. stokesii* and has been synonymised with it by Aplin and Smith (2001) who examined all recent collections of the species from Dirk Hartog Island, Edel Land and Peron Peninsula in the Shark Bay region. The disjunct populations of *E. stokesii* in central southern and eastern Australia are occasionally referred to as a separate subspecies, *E. s. zellingi.*

An unusually dark coloured specimen, currently recognized as *E. s. badia*, has been collected from Woolgerong Rock that lies well inland of all other records. A similar individual has also been sighted at a breakaway 4 km east of Yalgoo (G. Harold pers. comm.). These may represent yet another regionally distinct form of *E. stokesii.*

While the island populations of *E. s. stokesii* on the Houtman Abrolhos remain numerous within their restricted ranges, the mainland *E. s. badia* has suffered a major decline over the past century as a consequence of land clearance, especially in the central Wheatbelt (Storr *et al.* 1999). *Egernia s. badia* is currently listed as "fauna that is rare or is likely to become extinct" in the Wildlife Conservation (Specially Protected Fauna) Notice 2001 (Government of Western Australia 2001) and placed in the 'endangered' category, but at the time of this survey in 1998 was believed to be 'critically endangered'.

The biology of *E. stokesii* is relatively well understood due to the recent work of Bull and co-workers with literature reports detailing their occurrence in small groups (Gardner *et al.* 2001), their diet (Duffield and Bull 1998), production of live young and their preferences for hollow logs and rocky outcrops where they are active during the day (Greer 1989). It is also very likely that individual *E. stokesii* have a potential longevity in the order of several decades. Of particular significance, however, is the behaviour of several *Egernia* species, including *E. stokesii*, in depositing faecal droppings in a concentrated cluster outside their refuges (Cogger 1992, Wilson and Knowles 1995, Greer 1989, Pearson pers. comm.). These distinctive droppings have been used to determine the presence of this species during faunal surveys.

This paper reports on an assessment of the status of *Egernia stokesii badia* in the central and northern Wheatbelt region until the end of 1998.

METHODOLOGY

The past and present distribution of *E. s. badia* was investigated through consideration of all known localities of museum specimens and unpublished data, and current field surveys. During current surveys information on surviving populations of *E. s. badia* was sought from members of the community through approaches to both amateur herpetologists and local farmers.

Field surveys were undertaken to assess the current status of *E. s. badia* within the central and northern Wheatbelt region,

focussing on previously known collecting localities and any major unsampled woodlands within the known core distribution area of the species. During searching of likely habitats, particular use was made of the previously mentioned behavioural trait of the species in leaving faecal piles outside occupied logs and stumps. Presence of fresh faecal piles was taken as evidence of the species persistence in an area, and old faecal piles were taken as evidence of its presence in the recent past.

RESULTS AND DISCUSSION

WA Museum data

The WA Museum has specimens from 28 localities in the northern and central Wheatbelt region. The date of collection of these specimens is presented graphically in Figure 1 with the first record being in 1917. All of the 28 locations where *E. s. badia* has been recorded in the Wheatbelt (except Rothsay) lie within the "Avon Wheatbelt" IBRA bioregion of Western Australia (Thackway and Cresswell 1995). The majority of these collecting locations are from bushland reserves associated with the railway sidings established to handle harvested grain crops. One record from Hampton Hill, 25 km east of Kalgoorlie, from 1930 is believed to be that of an individual moved there during the period of extensive timber transport to the Goldfields for mining; no recent records have been made in this region.

There has been a marked decline in the number of specimens accessioned into the collections of

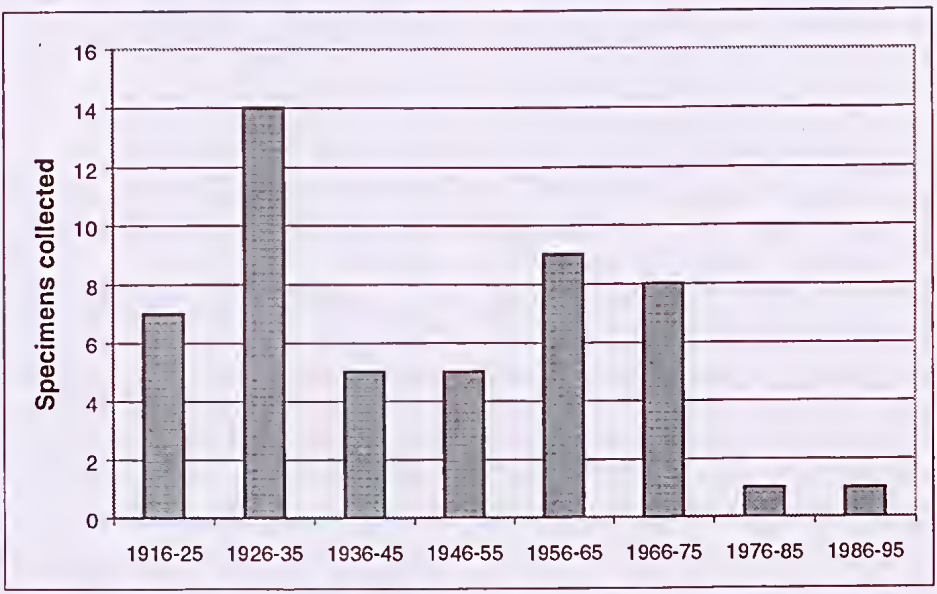

Figure 1. Decade of collection of specimens of *E. s. badia* lodged in the Western Australian Museum.

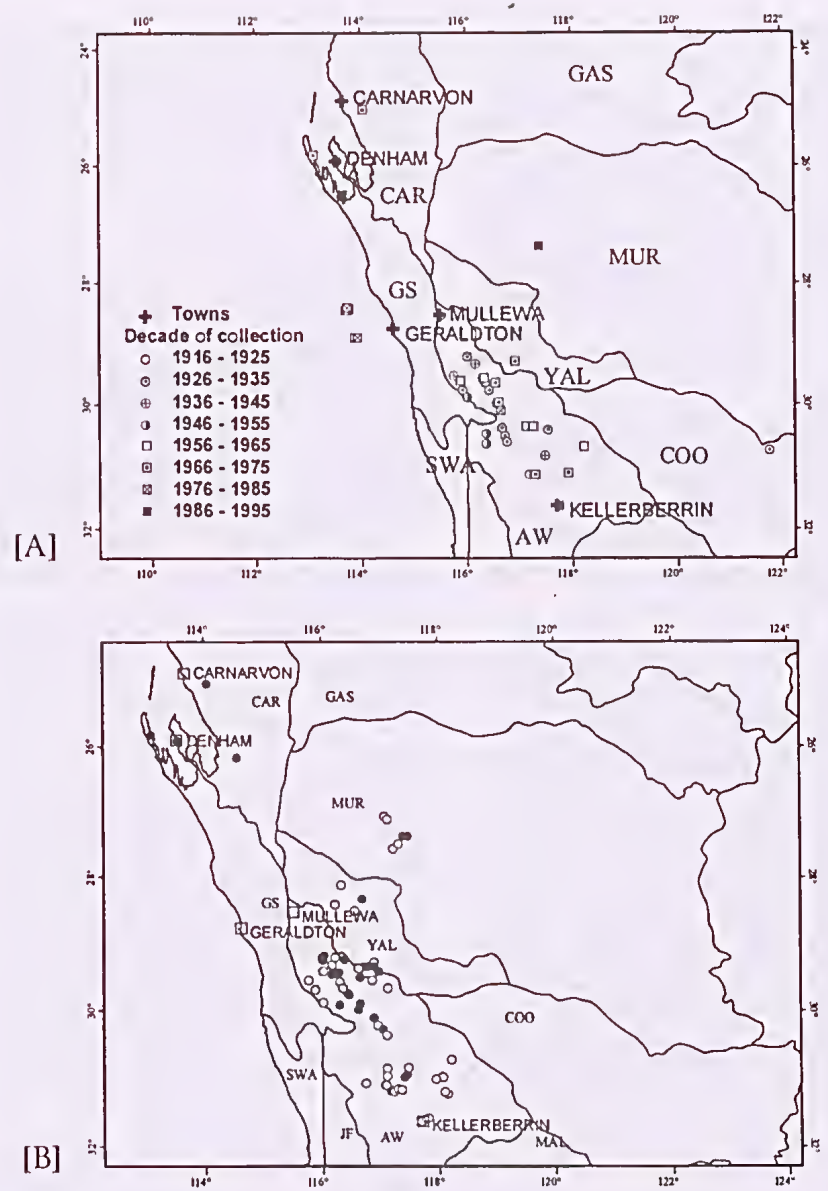

Figure 2. [A] Distribution of *E. stokesii* as represented by speeimen localities from the Western Australian Museum and identified by deeade of collection. [B] Distribution of *E. s. badia* as determined from recent field surveys by the authors and other herpetologists between 1996 and 2000. Closed eireles represent extant populations, open eireles loeations without evidenee of *E. s. badia*. Prineipal towns and IBRA regions are identified; AW Avon Wheatbelt, CAR Carnarvon, COO Coolgardie, GAS Gaseoyne, GS Geraldton Sandplains, JF Jarrah Forest, MUR Murchison, SWA Swan Coastal Plain, YAL Yalgoo.

the Western Australian Museum over the past 25 to 30 years. This fact, coupled with the large scale clearance of vegetation in the region in the past 40 years, has raised concern as to the long term survival of the subspecies in the Wheatbelt part of its distribution and led to its ranking as 'critically endangered' and listing as "rare or likely to become extinct" (Western Australian Government 1997).

The location of all collection sites of *E. s. badia* specimens in the WA Museum collection are presented in Figure 2a together with the distribution of specimens of *E. s. stokesii* and the unusual Woolgerong Rock colour form.

The locality of Caron, south of Perenjori, with six specimens has provided the greatest number of individuals in the collection of the WA Museum, while numerous other locations in the Wheatbelt have been the source of more than one specimen.

During the 1970's, the WA Museum surveyed 23 reserves throughout the Wheatbelt (Kitchener *et al.* 1980). This species was encountered on only one of these reserves. Over the last decade, one definite sighting has occurred in the northern Wheatbelt region – an adult in a small reserve near Mullewa (B. Maryan pers. comm.).

The central Carnarvon Basin population is poorly known, with only two definite localities (Callagiddy and Woodleigh Stations). The species was not encountered during the Carnarvon Basin Biological Survey during 1995–1996 (McKenzie *et al.* 2000) but, subsequently, has been seen on Woodleigh Station (B. Maryan pers. comm.). This northern population of *E. s. badia* may well be disjunct from that in the Wheatbelt.

Field Survey Results

We conducted field surveys in January, April and June 1998 to determine the current status of *E. s. badia* populations in the central and northern Wheatbelt of Western Australia. Over 80 locations within the Shires of Yalgoo-Mt Magnet, Three Springs, Carnamah, Perenjori, Morawa, Coorow, Moora, Dalwallinu, Wongan-Ballidu, Koorda, Dowerin, Mt Marshall, Wyalkatchem, Trayning, Kellerberrin, Nungarin, and Merredin were examined. These areas ranged in size from over 400 ha to less than one hectare.

The presence or otherwise of the species was determined by observing characteristic faecal piles outside hollow refugia or actual observation of individuals. The locations examined for *E. s. badia* are presented in Figure 2b with presence of the species denoted by closed circles and a suspected absence by open circles.

In 1972, a WA Museum survey team documented the presence of this species on Buntine Nature Reserve (No. 26837) and a specimen had been collected from Buntine in 1953. This Nature Reserve was re-examined in January 1998 and a single individual was captured in a hollow Gimlet (*Eucalyptus salubris*) log at the 1972 capture locality (Loc 1.5, Kitchener *et al.* 1979). An

hour-long survey at this site in January 1998 revealed six other logs or log piles in Gimlet/Salmon Gum (*E. salubris*/ *E. salmonophloia*) woodland with fresh faecal deposits. It appears that a healthy population still persists at this location on Buntine Reserve.

Two other individuals were collected during our 1998 surveys, one from a large log in York Gum (*Eucalyptus loxophloeba*) woodland on Bowgada Nature Reserve, the other from under disused railway sleepers in the Perenjori township. In addition, four individuals were marked and released from another colony under a woodpile in the backyard of a house at Perenjori.

The mummified skeleton of a hatchling *E. s. badia* was collected from under logs in York Gum woodlands south of Rothsay, while another mummified large adult was obtained from under a York Gum log adjacent to an abandoned farmhouse east of Morawa on the Yalgoo road. Skeletal remains of *E. s. badia* were collected within two faecal piles in York Gum woodlands; one east of the Wheatbelt and the other from a bushland remnant in a wheat paddock east of Wubin.

A captive colony, maintained at the Perth Zoo, of *E. s. badia* were all derived from a colony in an abandoned house just south of Perenjori (Russell Trehair, Perth Zoo, pers. comm.).

A four-day survey of woodlands and rocky outcrops north of Morawa and into the Mt Magnet Shire was undertaken to follow up locations of both typically patterned and 'melanic' *E. s. badia*. This survey failed to locate previously documented 'melanic' populations of the species from a breakaway 4 km east of Yalgoo and at Woolgerong Rock (G. Harold pers. comm.). Ten other locations were also examined for this unusual colour morph of *E. s. badia*. Four adult 'melanic' *E. s. badia* were observed by Russell Brown, two were seen deep in a single granite crevice on Woolgerong Rock and the others in separate crevices on Wurrah Rock. All the crevices were large and horizontally orientated with associated basking ledges. Skink faeces were noticed only outside one Wurrah Rock crevice.

A detailed survey of Woolgerong and Wurrah Rocks was undertaken in late June 1998 by herpetologists Brad Maryan, Robert Browne-Cooper and Brian Bush. This survey was initiated to gather further information on the habits and habitats of the 'melanic' form of *E. s. badia* and to obtain a specimen for molecular studies. A total of eight hours was spent searching the Rocks, resulting in the collection of a single adult. This specimen was collected from a crevice high on Wurrah Rock with both the crevice and basking ledge facing east. Faeces were collected from a deposit on the basking ledge. The remaining crevices were at the base of the rock. A search of Ulogunna Rock the following day failed to indicate the presence of *E. s. badia*.

Surviving Populations

The collection of individuals or skeletons of *E. s. badia* from Buntine Nature Reserve, Bowgada

Nature Reserve, Perenjori town and in York Gum woodland south of Rothsay and northeast of Morawa indicate that the species is still located over a large part of its previously known range in the eastern part of the northern Wheatbelt. Similarly, the recording of recent faecal piles adjacent to refuges in hollow logs at a further 10 *Eucalyptus* woodland sites as far south as Kalannie indicates that active colonies persist at numerous locations throughout part of the previously known range of *E. s. badia*.

However, none of the sites examined in the central Wheatbelt in the Shires of Dowerin, Mt Marshall, Wyalkatchem, Trayning, Kellerberrin, Nungarin, and Merredin revealed any current presence of this species. These sites included over a dozen localities from where specimens had been previously collected.

All of the sites where *E. s. badia* was recorded confirmed the assertions by previous authors that one of the species' preferred habitats was hollow logs. Most of the occupied sites were in York Gum woodland, although some were also in Gimlet and Salmon Gum woodlands. In all of the woodland sites surveyed the species occurred only where there were considerable numbers of large fallen logs over 25 cm in diameter. Preferences appeared to be for log piles where several overlapping hollow logs provided numerous openings as well as cover.

Assessment of the size and number of pellets in faecal deposits indicated that the populations with the greatest number of individuals were those associated with areas where suitable logs were abundant and grazing by domestic stock was least. Dispersal of young between logs may be disrupted by the presence of cattle or sheep, such that the long-term survival of populations in grazed woodlands may not be assured.

Two traverses east of Perenjori, through wheatfields into uncleared land, indicated that *E. s. badia* can persist in very small remnants of York Gum woodland surrounded by shrublands. The species persists in woodlands as small as 1 ha, although several other small (< 5 ha) patches failed to show evidence of their persistence. York Gum woodlands surrounded by wheatfields also retained populations of *E. s. badia*. Farms in the Perenjori shire retain populations of *E. s. badia* in old abandoned farmhouses, sheds and woodpiles (D. Robinson unpublished).

The continued persistence of the species in York Gum woodlands represents the best prospects of survival over part of its former range. Reintroduction to sites where the species occurred previously is a feasible proposition. Populations occupying "threatened localities" (abandoned buildings, farm sheds etc.) could be translocated provided suitable habitat (eg old hollow logs) is established at translocation sites and taking into consideration the social family structure of the species (Gardner *et al.* 2001).

The discovery of *E. s. badia* populations in York Gum wood-

land east of the cereal growing areas is of major conservation significance. This is an extension of the previously known distribution into the Yalgoo IBRA region. It is also significant that a 'melanic' form of *E. s. badia* is distributionally disjunct from the typical form and occupies rock outcrops rather than woodlands. This population warrants further investigation to determine its genetic and conservation status.

ACKNOWLEDGEMENTS

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FROM FIELD AND STUDY

An observation of *Acritoscincus trilineatum* in a Wedge-tailed Shearwater colony on Rottnest Island – As its common name suggests, the South-western Cool Skink *Acritoscincus trilineatum* (formerly *Bassiana trilineata*) occurs in temperate, south-western Australia, where it is generally associated with lakes, swamps, water courses and other damplands (Bush *et al.* 1995; Storr *et al.* 1999). *A. trilineatum* has previously been recorded on Rottnest Island, off the coast of Perth, Western Australia, where it was described as 'scarce' (Storr 1984) and 'uncommon' (Brooker *et al.* 1995). The Western Australian Museum has six specimens from Rottnest Island; one collected in each of 1954, 1960 and 1961, with no specific location details, and three collected in 1986 from the Bickley Swamp area (data courtesy of R. How). The most westerly recording of this species on Rottnest Island is Narrowneck (J. Dell, pers. comm.). Storr (1984) noted that *A. trilineatum* was confined to damp areas in the vicinity of freshwater seepages, but recent biological surveys on the island suggest that the species is not so strictly associated with swamps or seeps (J. Dell, pers. comm.).

On 14 May 2003 I hand-captured a single, live specimen while working in the Wedge-tailed Shearwater *Puffinus pacificus* colony at Radar Reef, on the south-western tip of Rottnest Island. The snout-vent length of the animal was 43 mm, the total length 119 mm and it weighed 1.7 g. The site of capture was less than 2 m above sea level, and within 10 m of the edge of the reef platform (0354244 E, 6455582 N). The surrounding vegetation was dominated by Iceplant *Mesembryanthemum crystallinum* and Coastal Saltbush *Atriplex cinerea* growing in coarse sand over the shearwater burrows. This capture represents a westerly extension of the range of *A. trilineatum* on Rottnest Island.

Characteristics of the site are comparable with the known ecological requirements of *A. trilineatum*. *M. crystallinum* is a succulent annual, that traps a humid air layer between its foliage and the ground surface (Rippey and Rowland 1995; W. Bancroft pers. obs.). Although this plant dies off by mid-summer each year, the combination of *M. crystallinum* and the shearwater burrows obviously provide suitably humid refugia to support *A. trilineatum*.

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Observations of *Aprasia repens* on Rottnest Island – Worm lizards in the genus *Aprasia* are predominantly fossorial and their ecology is not well understood (Storr *et al.* 1990; Webb and Shine 1994; Cogger 2000). Existing information has largely been deduced from dissection of museum specimens (Webb and Shine 1994). Opportunistic observations of the behaviour of live specimens are therefore particularly valuable in supplementing the museum data.

On 14 April 2003 I unearthed two separate pairs of the Southwestern Sandplain Worm Lizard *Aprasia repens*, while collecting soil samples at Radar Reef, Rottnest Island (0354463 E, 6455883 N). Remarkably the two unearthings came from only five localised instances of soil sampling. Both pairs were located within 30 mm of the soil surface in a dense mat of roots and were associated with the underground burrow systems and nests of the ant *Camponotus* sp. The surface vegetation was dominated by *Olearia axillaris*, *Westringia dampiera*, and *Acanthocarpus preissii*. These observations support previous findings that *A. repens* frequent root mats (Cogger 2000), and that they forage predominantly on ant larvae and pupae (greater than 95% of gut contents: Webb and Shine 1994).

Each of the Rottnest Island pairs comprised one larger (approximately 110 mm) and one smaller (approximately 90 mm) individual in close proximity (10–30 mm). A study by Patchell and Shine (1986) measured *A. repens* specimens from the Sydney Museum and found mean snout-vent lengths (SVL) of were 83.7 mm for males and 108.0 mm for females. Similarly, for Western Australian and South Australian specimens, Webb and Shine (1994) reported mean SVL of 89.9 mm and 107.8 mm for male and female *A. repens*, respectively. It is likely that each of the Rottnest Island pairs comprised a male and female animal.

While the timing of copulation and fertilisation has not been recorded for *A. repens*, Webb and Shine (1994) noted that females were gravid during November and December, and males had enlarged testes from August to November. It is probable that *A. repens* oviposits immediately after a spring mating. If my observations represent reproductive pairs, then

perhaps *A. repens* stay paired following such a mating.

Monogamy has been recorded in several species of reptiles, and is more commonly short-term (hours to days; Bull 2000). In the Australian Slcepy Lizard *Tiliqua rugosa*, however, monogamous pairs form for six to cight weeks prior to mating, although the partners separate immediately following the mating (Bull 2000). My observations of *A. repens* pairs, at a time that is probably several months post-mating, are anomalous. Further investigation will be requircd to determine whether the reproductive ecology of *A. repens* is a unique case, or whether my observations were simply chance events.

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Buff-banded Rail breeding at Pelican Point – On Saturday 30 August 2003 I found a single, broken Buff-banded Rail *Gallirallus philippenis* egg-shell, in the Pelican Point Nature Reserve, Crawley. This finding is the first proof of these birds breeding at Pelican Point. The egg-shell was found under a clump of Sea-rush *Juncus krausii*, about 15 m from the nearest edge of the estuarine ponds. Although about one quarter of the eggshell was missing, the patterning was clear and I was able to measure its dimensions (c. 37 mm x 25 mm) to allow positive identification of the egg (Johnstone and Storr 1998).

The location of the egg was consistent with what is known of the breeding biology of Buff-banded Rail. The species prefers to nest among long grass, rushes, reeds or sedges in saltmarshes, usually near water, and laying commences in August or September in southern Australia (Marchant and Higgins 1993). Buff-banded Rail have been recordcd brecding in similar habitat elsewhere on the Swan Coastal Plain (e.g. Bibra Lake, Lake Gwelup, BAWA 2003).

The Pelican Point Reserve has been surveyed on a weekly basis during summer since at least 1972, and on a weekly basis all year around for the last three years, yet Buff-banded Rail have not been recorded breeding at the site

(Johnstone and Storr 1998, K. Creed, pers. comm.). In recent years Buff-banded Rail have been regularly observed (23% of visits in 2001, and 17% of the 2002 surveys, K. Creed unpub. data), and, on occasion, small parties of birds, including individuals that were thought to be immature, have been noted (3, 21/11/2001; 4, 06/01/2002; 3, 10/02/2003; K. Creed unpub. data). Given the apparent increase in Buff-banded Rail abundance on the Swan Coastal Plain in recent years, it is not surprising that there is now proof of their breeding at Pelican Point.

My thanks to Kate Creed for supplying the historic survey information for Pelican Point.

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Predation of Loggerhead turtle hatchlings by the Boodie (*Bettongia lesueur*) on Dorre Island, Western Australia – The Boodie is a nocturnal and gregarious macropod that inhabits burrows of its own construction. It is omnivorous, feeding on invertebrates, seeds, fungi, fruit, nuts, and carrion (Burbidge 1996, Robley *et al.* 2001). At the time of European settlement the Boodie was wide spread across the southern two thirds of Australia, but is now confined to four islands off the Western Australian Coast (Short and Turner 1999, Morris 2002).

During a visit to the northern end of Dorre Is (60km west of Carnarvon, WA) in March 2003, it was observed that over 20 Loggerhead Turtle (*Caretta caretta*) nests had been dug up and the emerging hatchlings taken within the previous 24 to 48 hours. Fresh Boodie tracks were found in and around the nests. Boodies had excavated an area approximately 1m across and had dug down 450 to 500mm to expose the nesting chamber and the egg shells of the emerging hatchlings. Loggerhead Turtles are the most threatened turtle in WA waters.

It was noted that there had been a significant predation of the hatchlings as there were few hatchling tracks leaving the nest; in most cases less than six sets of tracks were observed. It would be expected that significantly more hatchlings than this would leave a nest: on Dirk Hartog Island the average number of eggs per clutch is 141 (Prince 2000). It appears that the predation was opportunistic

and coincided with the emerging of the hatchlings. All the Boodie excavations were centred above the nesting chambers and it appears that they were targeting the hatchlings as they emerged, although it is possible that they may also take the eggs there was no evidence of this.

Live Loggerhead Turtle hatchlings were found just below the surface of one exposed nest and it would be likely that high daytime temperatures would have killed these hatchlings. These observations indicate the Boodie on Dorre Island is potentially a significant cause of mortality of turtle hatchlings on the island. Recent Water Rat (*Hydromys chrysogaster*) tracks were also found in the area but it is uncertain whether they are taking the hatchlings. Western Barred Bandicoots (*Perameles bougainville*) also occur on the island, but it is unlikely this species would be capable of taking hatchlings; however, on Barrow Island it has been recorded that the Golden Bandicoot (*Isoodon auratus*) is capable of taking the eggs of Green Turtles (Morris 1987). There is no evidence that Boodies on Barrow Island take turtle hatchlings (Burbidge pers. comm.).

It would appear, from the number of disturbed nests that Dorre Is may be a significant Loggerhead Turtle rookery and the site and impact of Boodie predation of the hatchlings warrants further investigation.

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CLUB NEWS

Programme

General Meetings and Branch Meetings are held at various venues in Nedlands, Kalamunda, Rockingham and North Beach.
The Retired and Leisured Group meets on alternate Wednesdays at 10a.m.
Excursions and field days are planned from time to time and will be advertised in the Club's monthly newsletter "The Naturalist News".

THE WESTERN AUSTRALIAN NATURALIST
(Journal of the W.A. Naturalists' Club)

Editor
MR JOHN DELL

The Western Australian Naturalist publishes original data on all branches of natural science pertaining to Western Australia. Originals and two copies of manuscripts should be submitted to the Editor for review by two referees. Authors are requested to follow current editorial style. If possible, manuscripts should be submitted on an IBM compatible 3½ disk in Word format. High quality illustrations suitable for some reductions in size are preferred.

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